EDN®

THE DESIGN MAGAZINE OF THE ELECTRONICS INDUSTRY

AUGUST 18, 1994

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Project Plowshare:
Putting military technology to other uses

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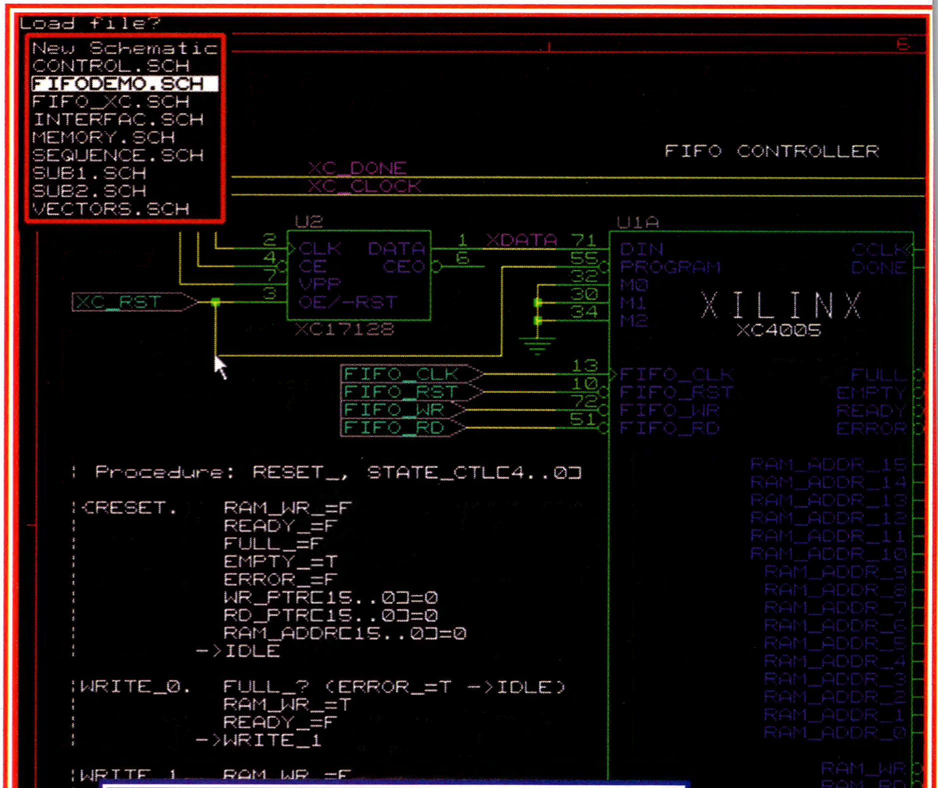

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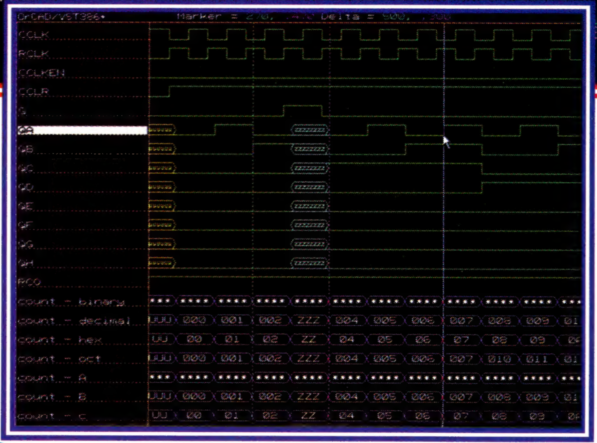
Load file?
New Schematic
CONTROL.SCH
FIFODEMO.SCH
FIFO_XC.SCH
INTERFAC.SCH
MEMORY.SCH
SEQUENCE.SCH
SUB1.SCH
SUB2.SCH
VECTORS.SCH
```

```
: Procedure: RESET_, STATE_CTL[4..0]

:(RESET.      RAM_WR_=F
:             READY_=F
:             FULL_=F
:             EMPTY_=T
:             ERROR_=F
:             WR_PTR[15..0]=0
:             RD_PTR[15..0]=0
:             RAM_ADDR[15..0]=0
:          ->IDLE

:WRITE_0.     FULL_? (ERROR_=T ->IDLE)
:             RAM_WR_=T
:             READY_=F
:          ->WRITE_1

:WRITE_1      RAM_WR_=F
```



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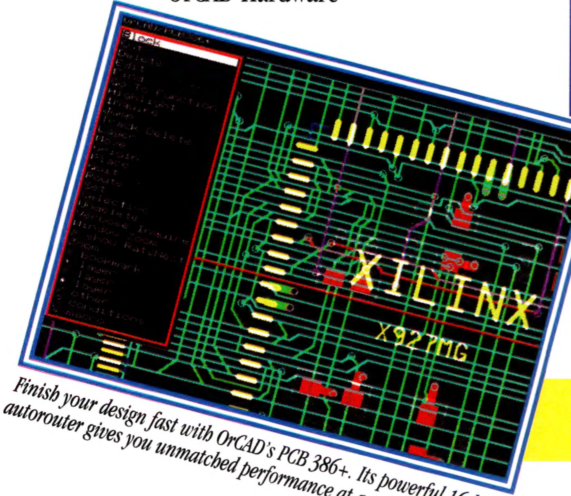

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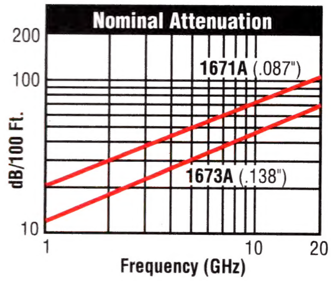

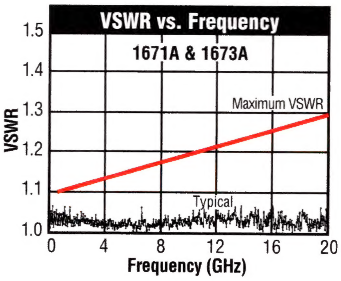

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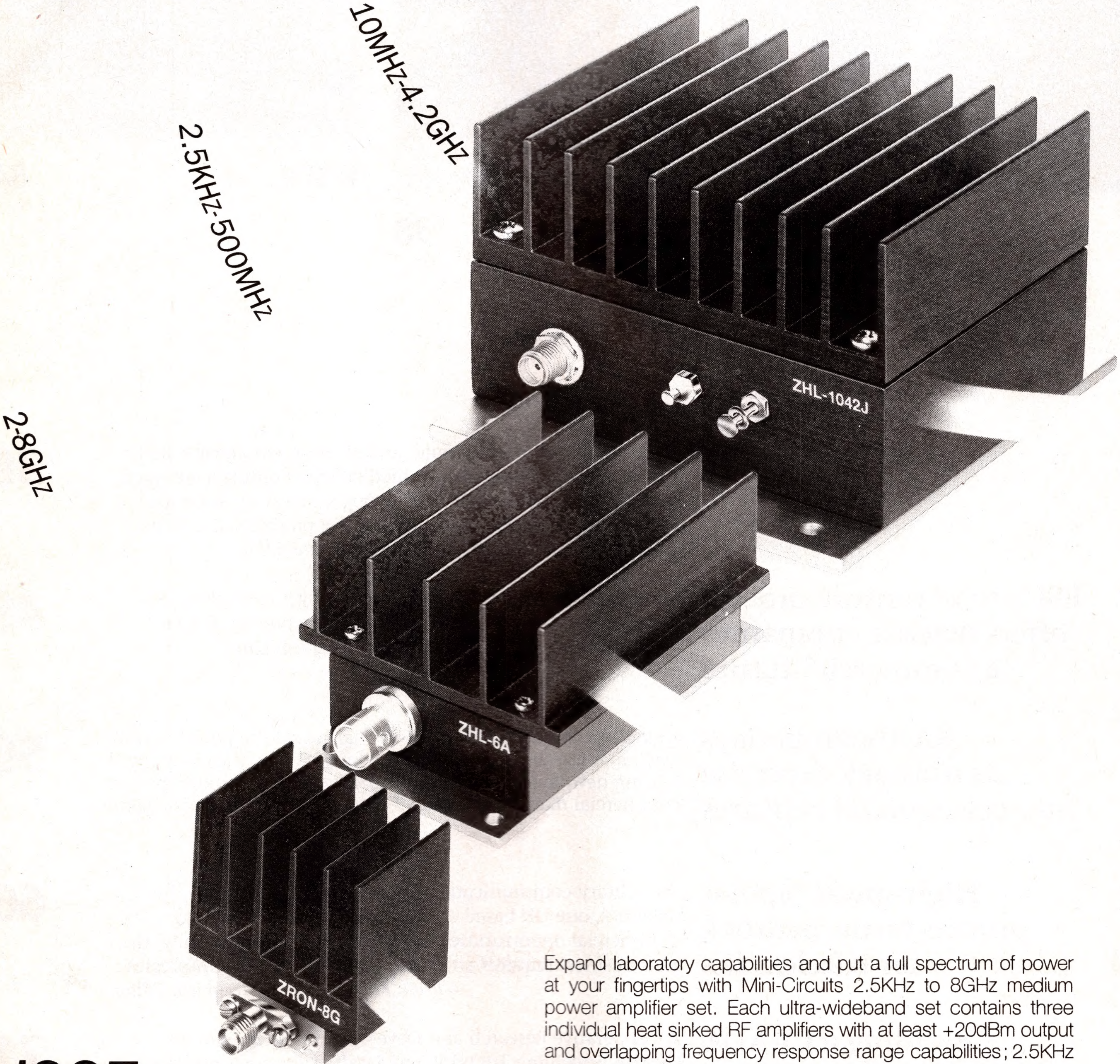

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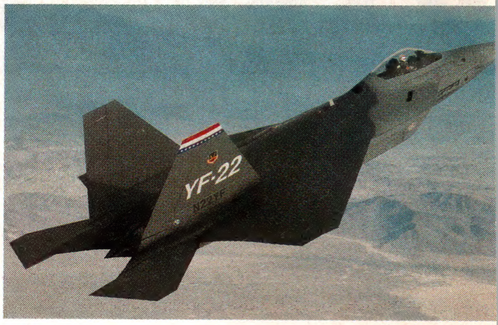
Peace can pay **38**



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Peace can pay

Or can it? Those in electronics and aviation who have relied exclusively on government-funded defense contracts are wary. But innovative businesses with strong survival instincts are stirring up new applications for military products and technologies.—*James P Leonard, Senior Associate Editor*

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ESL's new-venture process offers defense companies a commercial future

The Cold War's end brought defense-budget reductions. So defense contractor ESL Inc found a way to pursue civilian opportunities.—*Richard A Quinnell, Technical Editor*

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Raytheon parlays its military expertise into commercial ventures

Following World War II, Raytheon harnessed the power of military radar to invent microwave cooking. Today, the company is finding new opportunities to diversify defense technology into commercial markets.—*Frances T Granville, Senior Associate Editor*

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High-speed bipolar process forms bedrock for wireless ICs

As military-communications business drifts further to the sidelines, one UK-based company sees new and exciting commercial opportunities leap to the fore. Providentially, the new business requires an almost identical set of technologies.
—*Brian Kerridge, Senior Technical Editor*

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Building a CRADA

A Cooperative Research and Development Agreement, or CRADA, involving TriQuint and Sandia Labs demonstrates how to become allies in technological breakthroughs.—*Gordon Cumming, TriQuint Semiconductor, and James A Heise, Sandia National Laboratories*

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Israel and America team up for conversion

The US Binational Industrial R&D Foundation pairs a US company that is strong in its market with an Israeli company with novel technology.—*Alberto Socolovsky, Contributing Editor*

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VHDL emerges as a commercial design tool

Despite the initial challenges imposed by VHDL, the language, born of the military, has made the commercial sector sit up and take notice.—*Karen Bartleson, United Technologies Microelectronics Center*

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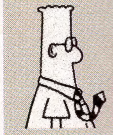
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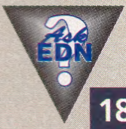

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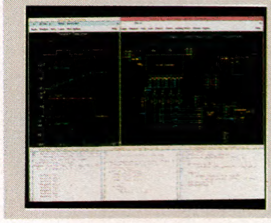
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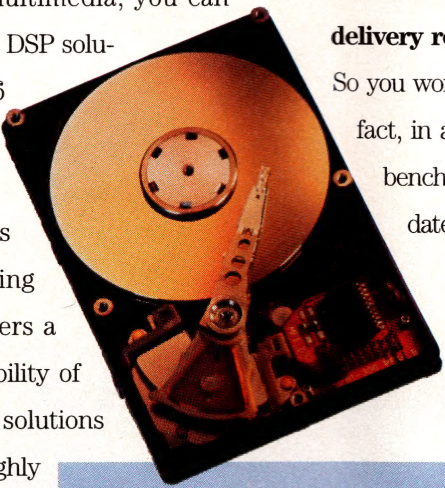

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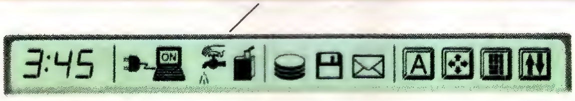

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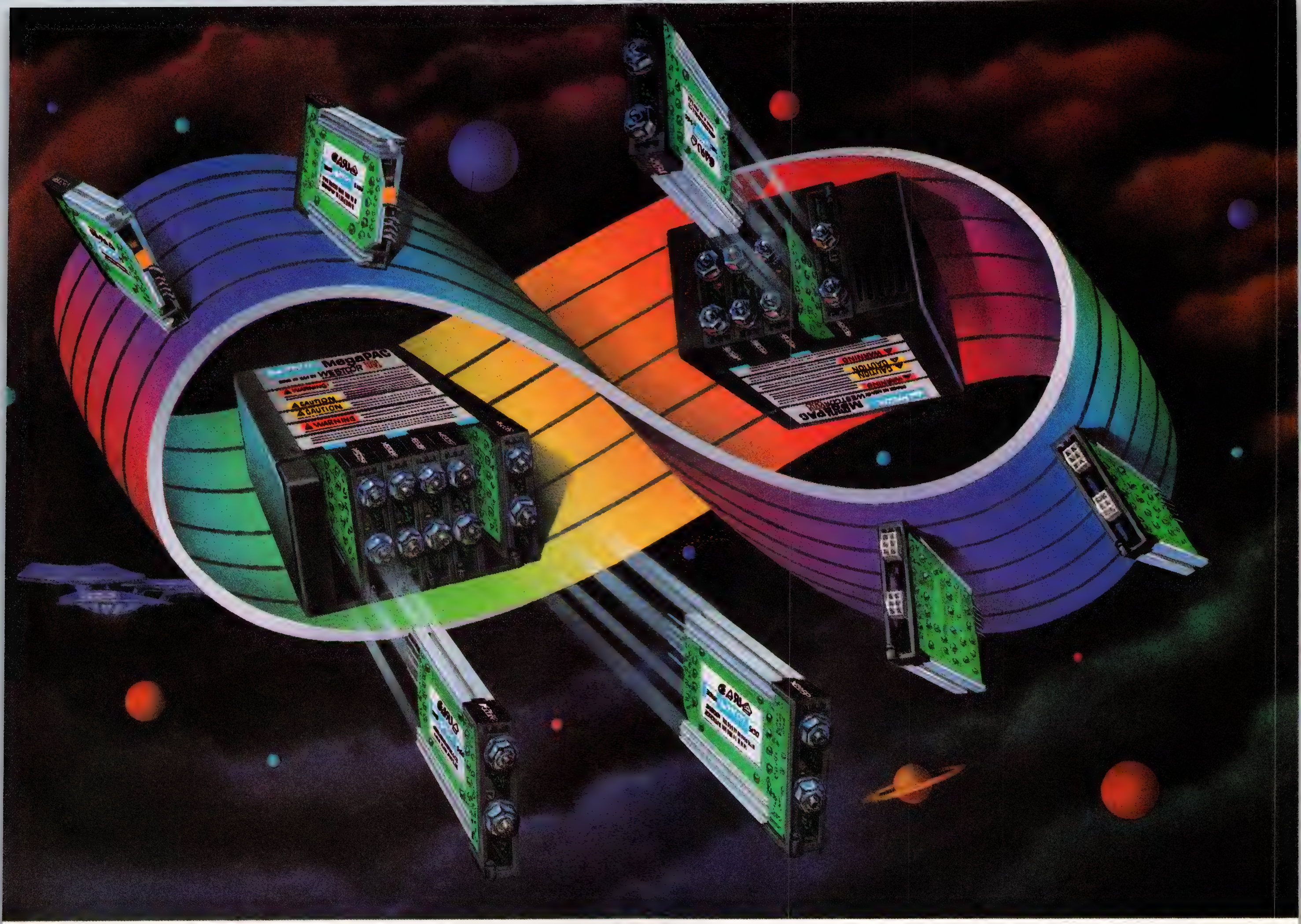

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Your opportunities are endless to mix and match MegaPAC options. And with so many possible power solutions available, you can define one precisely to fit *your* needs.

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NEW! Automatically senses line voltage and straps power supply accordingly.

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- Up to 100 or up to 200 watts per output
- 1-16 outputs, isolated & fully regulated
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ModuPAC slide-in converter assemblies:

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CIRCLE NO. 88

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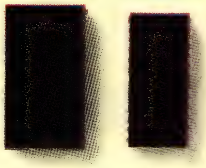
Samsung is among the first suppliers in the world to complete the 300-mil 16-meg. Partly because the



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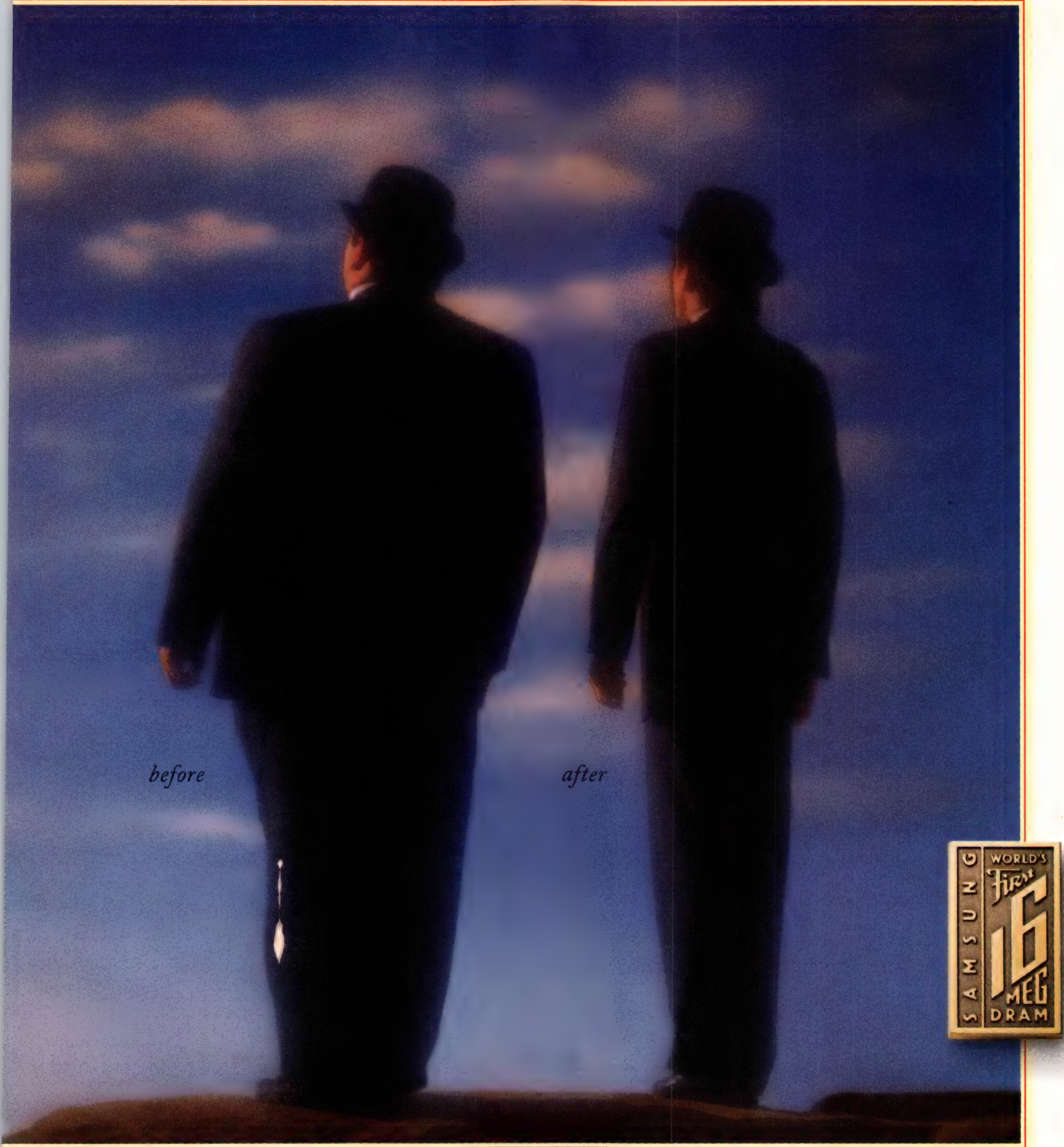

part's lead-on-chip construction—which is what makes it so much smaller than the now-standard part—is extremely difficult to manufacture. And building it marks one more in a long line of significant achievements in memory for Samsung.

We offer the 300-mil in both 5.0 and 3.3 volt. And if you build systems that benefit from a maximum of memory, you're probably going to want to take advantage of it—and all the width it lets *you* lose.

For more information, please call 1-800-446-2760 or 408-954-7229 today. Or write to DRAM Marketing, Samsung Semiconductor CA 95134.

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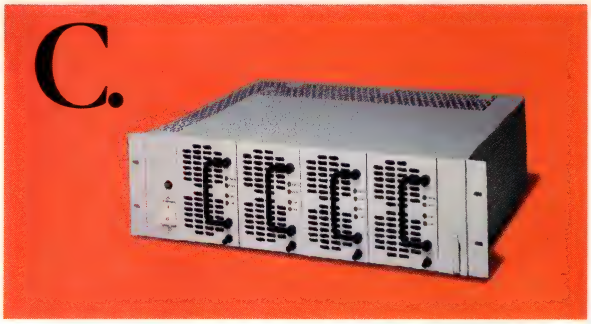
CIRCLE NO. 78

A.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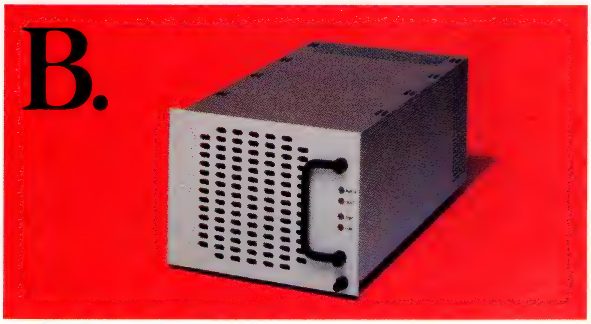
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D.

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AT&T's Enhanced Distributed Power Architecture offers the industry's most complete line of A) board-mounted dc-dc power modules, B) front ends, C) power shelves and D) battery reserves, for computers and communications. All with standard modular designs, to make specifying power supplies that much easier. And of course, everything we supply is backed by the reliability and support of AT&T Bell Labs.

When you work with AT&T, you don't have to source front ends from one vendor and hope they work with board-mounted dc-dc power modules from another. Or wait while everything from several vendors gets linked together.

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From one-half watt to 4,000 watts, AT&T's EDPA power systems really do give you the power to do more. For more about the advantages of AT&T's Enhanced Distributed Power Architecture for a wide range of telecommunications, data processing and mass storage applications, call AT&T at **1 800 526-7819**.

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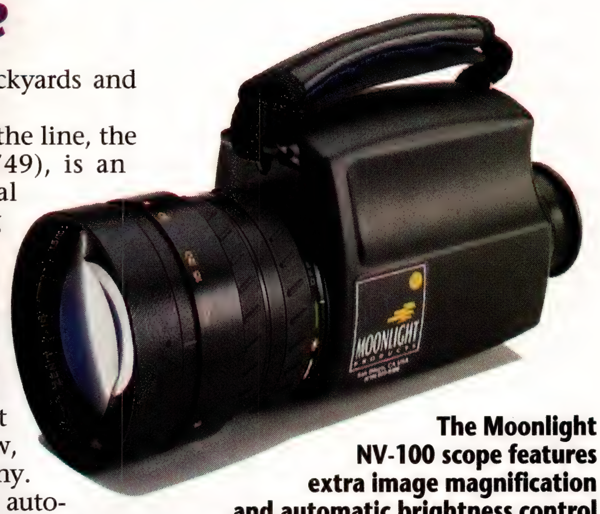
CIRCLE NO. 36

NIGHT-VISION PRODUCTS: *not just for the military anymore*

Until recently, the high prices ($3000 to $15,000) of night-vision devices kept them out of the range of most users. Low-cost models became available after factories in the former Soviet Union began selling the devices, which were designed for the military, on the commercial market. Moonlight Products carries a line of these devices, including scopes, binoculars, and goggles, with prices ranging from $459 for the palm-sized Moonwalker scope to $1999 for the MPN 50K-I night-vision goggles.

Although the company originally targeted the products at border-patrol and law-enforcement agents, people are buying the devices for recreation, such as boating, observing wildlife, and photography. A company spokeswoman says the devices fall into the "toys-for-boys" category; the company receives requests from people who want to "sit in their backyards and look at coyotes."

The latest addition to the line, the Moonlight NV-100 ($749), is an advanced electro-optical spotting scope featuring 10,000x light-amplification capabilities and 4.3x image magnification. The extra image magnification of the optics allows you to see longer distances than most night-vision devices allow, according to the company. The scope also features automatic brightness-control circuitry to protect against sudden exposure to bright lights and an adjustable lens diaphragm that extends the scope's range of vision into bright, urban areas as well as dark, wilderness settings.—by Anne Coyle



The Moonlight NV-100 scope features extra image magnification and automatic brightness control that allows you to use the scope in urban and wilderness settings.

Moonlight Products, San Diego, CA, (619) 625-0300. **Circle No. 400**

FPGA IS HIGHEST DENSITY, RADIATION-HARDENED

Space Electronics Inc (SEI) has introduced what it claims is the world's highest density, space radiation-hardened field-programmable gate array (FPGA). The 8000-gate FPGA can tolerate 100-Krad (si) total doses for most low-earth and geosynchronous orbits and can survive single-event latch-ups in excess of 120 MeV/mg/cm^2. The device is compatible with 1280A software tools from Actel and Texas Instruments.—by Gary Legg

Space Electronics Inc, San Diego, CA, (619) 452-4166. Circle No. 401

IC vendor takes aim at the high cost of high reliability

A flexible strategy is helping National Semiconductor Corp to provide products for defense and aerospace applications at costs that often are close to those of commercial parts. The strategy works even for multichip modules (MCMs), a technology that has a reputation for high costs. Customers can specify screening from commercial (dc only) to MIL-I-38585 (MIL-STD-883) or space grade—or any level in between. Packages can be plastic or hermetic. The company designs the process flow to meet the customer's needs. Certifications and paperwork are costly; customers who don't need them can save money.

In the case of MCMs, National offers only a few types as commercial, off-the-shelf (COTS) products. However, when such products exist, military and aerospace customers can obtain high-reliability versions for prices substantially lower than those of full-custom designs. The company's experience with manufacturing high-reliability MCMs also pays dividends to its commercial customers. The same business unit is responsible for both commercial and high-reliability MCMs. As a result, commercial customers get the benefits of processing improvements developed for military products.
—by Dan Strassberg

National Semiconductor Corp, *Santa Clara, CA, (408) 721-5000.* **Circle No. 402**

LOCKHEED SPIN-OFF WILL SELL COMMERCIAL SATELLITE IMAGES

Lockheed Corp has spun off a commercial entity, Space Imaging, which will begin selling high-resolution satellite images to the commercial market in 1997. Monochrome image resolution will be 1m compared with the current 10 to 15m resolution of commercial satellite images. In addition, the image data will be tagged with accurate positioning information. Space Imaging is contracting with Lockheed Missiles & Space Co (Sunnyvale, CA) to build imaging satellites.
—by Steven H Leibson

Space Imaging, Sunnyvale, CA, (408) 742-1801.

Circle No. 403

Real-time Navy computer adapted for commercial meterological use

When Lockheed (Austin, TX) and Concurrent Computer Corp developed the Tactical Environmental Support System (TESS) for the US Navy, it was used to provide ship commanders strategic weather and oceanographic information. When the companies saw a way to improve the antiquated weather systems in many countries throughout the world, they adapted TESS for commercial use.

The Meteostar LEADS (Lockheed Environmental Analysis and Display System) is the commercial off-the-shelf system. It employs Concurrent's Series 7000 real-time multiprocessing computer, which is based on one, two, or three Motorola 33-MHz 68040 CPUs. The system, which is tailored to meet the specific weather patterns of a particular country, is being used in Malaysia, by the Japanese self-defense force, and by the Tokyo broadcasting system. It costs approximately $125,000 to $300,000.—by Joan Lynch

Concurrent Computer Corp, Oceanport, NJ, (908) 870-4500.

Circle No. 404

Guide to military-technology conversion

The 1994 edition of *Economic Conversion Update* is the 11th edition of this guide to defense conversion. This $20, 53-pg report lists conversion resources, including people, organizations, and government agencies, and provides information on the most recent conversion activities at the federal, state, regional, and community levels. —by Steven H Leibson

Center for Economic Conversion, Mountain View, CA, (415) 968-8798.

Circle No. 405

Radar technology licensed for automotive safety applications

Drivers may soon receive some high-tech help in avoiding collisions, thanks to radar-based sensors. The Department of Energy's Lawrence Livermore National Laboratory developed the sensors using off-the-shelf components and licensed the technology to Amerigon Inc (Burbank, CA). The sensor includes a receiver that detects echoes of rapid, wideband radar pulses (about 1 million/sec) reflected from objects at distances from 0 to 200 ft.

A computer chip generates short electrical pulses (from 50 trillionths of a second to less than 1 billionth of a second), which the sensor then sends out, receiving back radar echoes. The device accepts echoes only from objects within set distances, adjusts to the objects within that environment, and detects any motion within those areas.

Amerigon anticipates using the technology to create onboard devices to signal for vehicles in a driver's blind spot and to act as backup-warning systems and parking aids. The system sends data about objects or vehicles near a car to the cruise-control system, a beeping alarm, or a system that inflates a side air bag before a side-impact crash. The sensor may also find applications in home security, medicine, and search and rescue.—by Anne Coyle

A radar-based sensor from Lawrence Livermore National Laboratory can improve automotive safety applications, including signaling for vehicles in a driver's blind spot, aiding in parking, and adjusting cruise-control systems.

Lawrence Livermore National Laboratory, Livermore, CA, (510) 422-1100.

Circle No. 406

DILBERT® by Scott Adams

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WHEN I STARTED PROGRAMMING, WE DIDN'T HAVE ANY OF THESE SISSY "ICONS" AND "WINDOWS."
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S.Adams
ALL WE HAD WERE ZEROS AND ONES -- AND SOMETIMES WE DIDN'T EVEN HAVE ONES.
9-8
I WROTE AN ENTIRE DATABASE PROGRAM USING ONLY ZEROS.
YOU HAD ZEROS? WE HAD TO USE THE LETTER "O."

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CIRCLE NO. 64

REFERENCE-MANUAL FOR LOAN

A In "Ask EDN," May 12, 1994, pg 39, William Quam requested information on an HP Model 400C voltmeter. We have a Model 400F ac voltmeter and, if it would be helpful, would loan him the manual.

Bernard Gershen
Leviton Manufacturing Co Inc,
Little Neck, NY (718) 229-4040

TROUBLESHOOTING FROM THE SOURCE

A I read Paolo Zambusi's request for information on the LTC-1043-based divider and multiplier circuits ("Ask EDN," June 9, 1994, pg 34). As the designer of these circuits, I felt obliged to reply. I know of no reason that the divider should produce the poor performance noted—assuming it's built and tested as originally specified. Some possible problems might be

- Polystyrene capacitors are a must because of their superior dielectric absorption. If poorer performing dielectrics are used, results suffer, most notably linearity.
- The component values listed in the schematics represent design-centered values for the input-output ranges and performance levels quoted. Deviations from these values to achieve different scale factors (or whatever) can have deleterious results unless all circuit interactors are evaluated. As an example, substantially increasing the charge-pump capacitor's value precludes complete charge-discharge cycles, degrading linearity. Similarly, altering input-voltage scale factors can have an equal effect. You can accommodate such changes by altering the positive-feedback hang-up time constant (30 pF, 22k).
- Finally, the performance specifications quoted are referred to as a percentage of full scale, not as a percentage of reading. It is crucial to understand this when interpreting results. This is a common source of confusion in evaluating all types of circuitry, and you should keep it in mind.

I hope these suggestions help. If not, I'll be glad to troubleshoot Zambusi's breadboard if he'll send it to me.

Jim Williams, Staff Scientist
Linear Technology Corp, Milpitas, CA

"Ask EDN" solves nagging design problems and answers difficult questions. Address your letters to Ask EDN, 275 Washington St, Newton, MA 02158; fax (617) 558-4470; MCI: EDNPRIME; Internet: EDNPRIME@MCIMAIL.COM. Or, send us a letter on *EDN*'s bulletin-board system at (617) 558-4241, 300/1200/2400 8,N,1. From the Main System Menu, enter ss/ask_edn and select W to write us a letter.

Technology gives memory densities huge boost

A new assembly technology for memory wafers and dice promises dramatically higher densities for packaged memory devices—ultimately as high as 1.25 Gbytes/in.^{3} with 16-Mbit DRAMs, compared with only 40 to 80 Mbytes in the same volume with conventional SOJ or two-sided TSOP packages. The first products using the technology will be available this year.

The technology achieves the higher densities through its method of stacking and connecting wafers and dice. A key feature is a patented, pyramid-shaped via through the silicon ***(Fig 1)****. The small opening on the top of the pyramid penetrates the silicon on the circuit side, and the large opening comes through on the back, where the interconnect makes contact with a number of circuit elements on the silicon directly below. This interconnect method takes no space because all pins fan out under the silicon stack instead of residing around the perimeter of the active silicon.*

The first products to result from the technology, due in the fourth quarter, are 88-pin, Type I PCMCIA cards with 16, 32, 64, and 128 Mbytes of DRAM. Expected prices are $1995, $3995, and $7995, respectively. —by Gary Legg

Cubic Memory Inc, Scotts Valley, CA, (408) 438-1887.
Circle No. 407

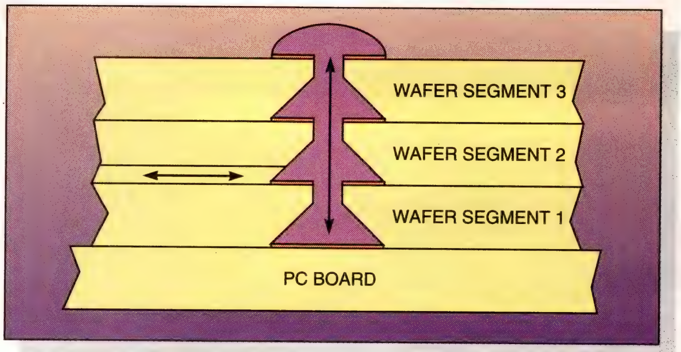
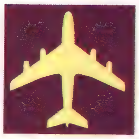


Fig 1—Pyramid-shaped vias connect silicon wafers and dice in a new technology for producing high-density memory devices.

AIRBORNE FIBER-OPTIC LANs COME OF AGE



Boeing's recently introduced 777 aircraft employs two fiber-optic LANs developed by ITT Cannon's Military/Aerospace Division for avionics and cabin systems. These applications represent the first major use of fiber-optic interconnection technology in a commercial aircraft. New optical components for the LANs include multichannel butt-joint and expanded-beam termini, connector and cable harness configurations, and multiswitch by pass-switch units. —by Steven H Leibson

ITT Cannon, Santa Ana, CA, (714) 261-5300. **Circle No. 408**

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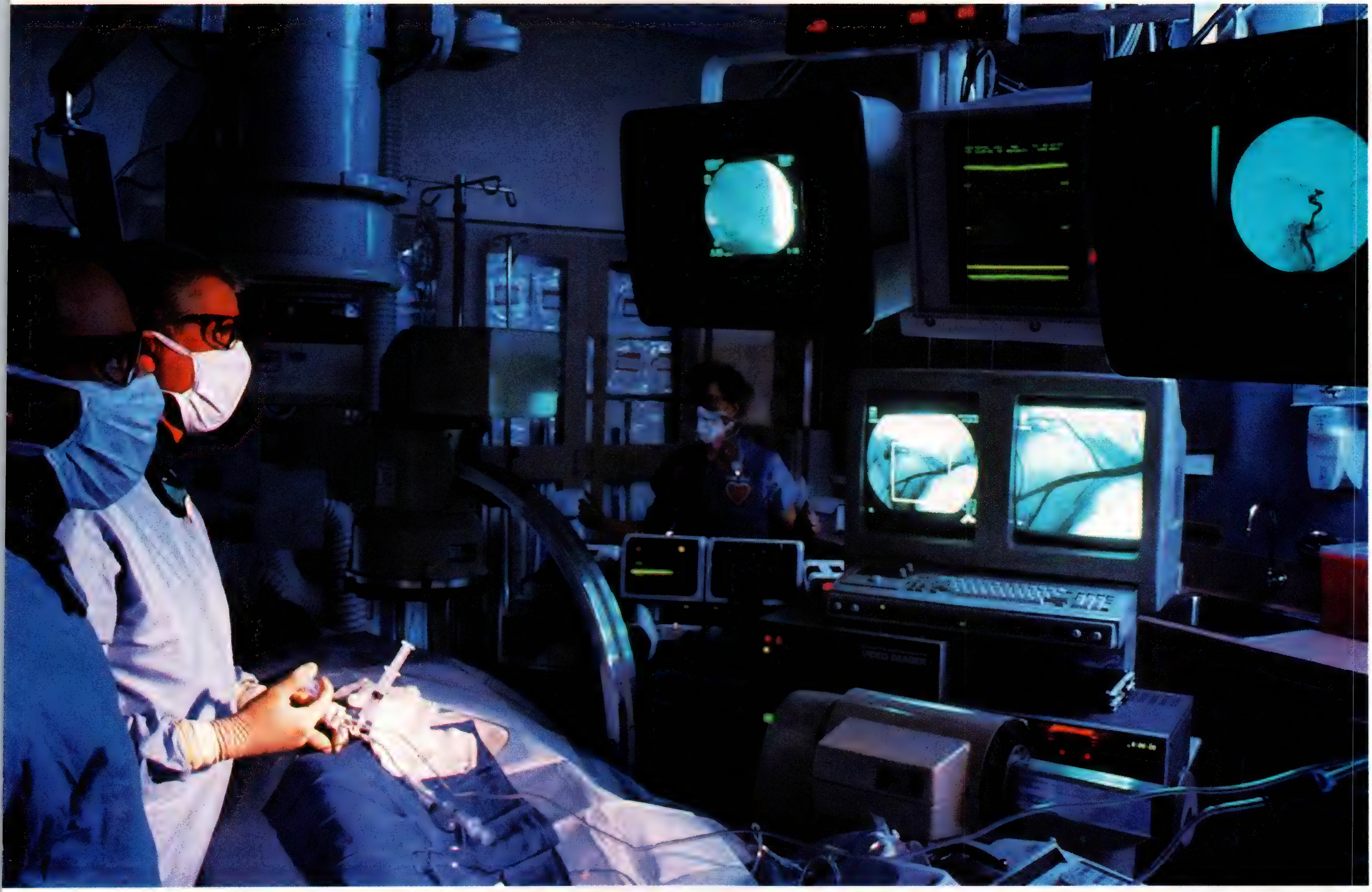

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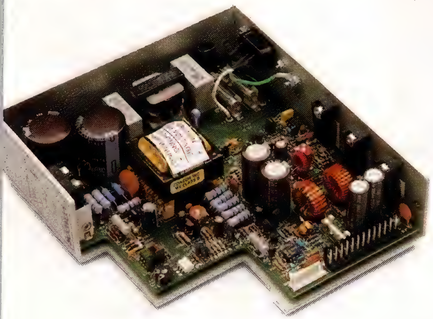

Our medical switchers and linears meet every international safety requirement, including IEC601, VDE0750, UL544 CSA1402-3 and CSA22.2 No. 125. Only Condor combines full agency approvals with so many great features, including:

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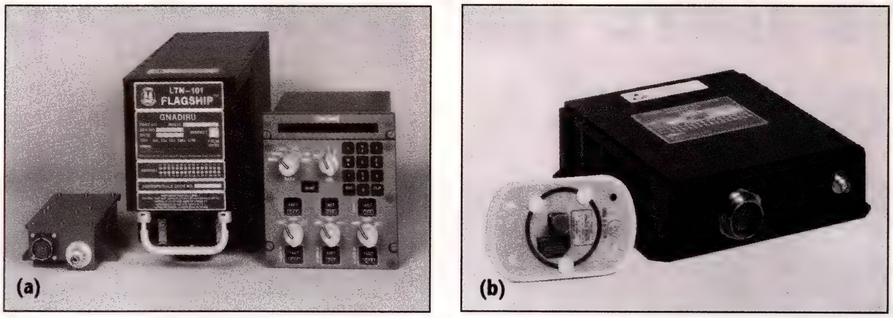
CIRCLE NO. 19

Inertial/GPS navigation system to fly on long-range jetliners



Litton's navigation systems integrate the LTN-101 Flagship laser-gyro inertial-reference systems (a) with the LTN-2001 GPS receivers (b).

Litton Industries recently announced two aircraft navigation systems that combine laser-gyro technology and global-positioning-system (GPS) satellite receivers. The LTN-101 Flagship laser-gyro inertial-reference systems combine with the LTS-2001 GPS receivers to fly aboard long-range commercial jetliners. A typical aircraft installation includes three LTN-101 units, two LTN-2001 GPS receivers, and eight air-data modules, eliminating the need for separate air-data computers and extensive pneumatic tubing throughout the aircraft.

The self-contained LTN-101 Flagship systems provide continuous navigational accuracy within 2 mph per flight. The LTN-2001 receivers provide geographic position accuracy within 100m, link that data to the aircraft's flight-management system, and update the navigational accuracy of the LTN-101s.

Airbus Industrie A340s of Virgin Atlantic Airways' and Lufthansa German Airlines' regular transoceanic flights will be the first aircraft to employ the systems. Sabena, Cathay Pacific, Philippine and UTA Airlines, Euralair, Austrian Airlines, Air Lanka, Thai Airways, and International Lease Finance Corp also plan to use the systems.—by Anne Coyle

***Litton Industries Inc**, Beverly Hills, CA, (310) 859-5907.*

Circle No. 409

* * *

Mixed-signal simulator extends digital HDLs into analog

Digital designers have been able to take advantage of standard hardware description languages (HDLs) for specifying and simulating designs. Until recently, analog designers could use proprietary analog HDLs to obtain the benefits of modeling systems behaviorally—instead of at the transistor level with Spice. Analog HDLs' advantages have primarily been in faster model development and reduced simulation time. Recently, Anacad EES, Analogy, and Mentor Graphics announced analog simulators that accept VHDL-A, an extension of the VHDL standard for analog circuits. Now Cadence is offering Spectre HDL, an analog behavioral-simulation system that accepts both VHDL-A and Verilog-A.

Neither VHDL-A nor Verilog-A is a standard yet. The Analog VHDL International (AVI) consortium of companies is working on the VHDL-A standard and expects to have an approved language reference manual (LRM) around the end of the year. Current tools that use VHDL-A are working from preliminary versions of the LRM. Verilog-A is based on a LRM that Cadence developed and submitted to the Open Verilog International (OVI) organization.

The company claims simulation-speed improvements of 10 to 100 times (or more) with the new simulation system. The simulation speed depends on the behavioral modeling level you use—higher-level models offering greater speed improvements.

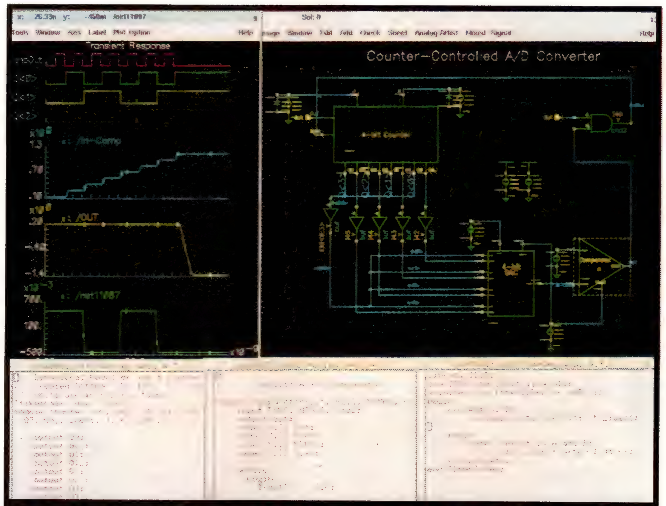
The company also offers the Resolve optimizer as an option that helps you generate behavioral models from Spice reference circuits. The tool works in an extract-simulate-optimize loop, refining the behavioral model until it agrees with the Spice circuit results to within 1 to 2%.

The behavioral analog simulator also integrates with the company's other simulators, letting you model part of a circuit in Spice, part in analog HDLs, and part in digital circuit blocks defined and simulated using VHDL, Verilog, or gate-level schematics.

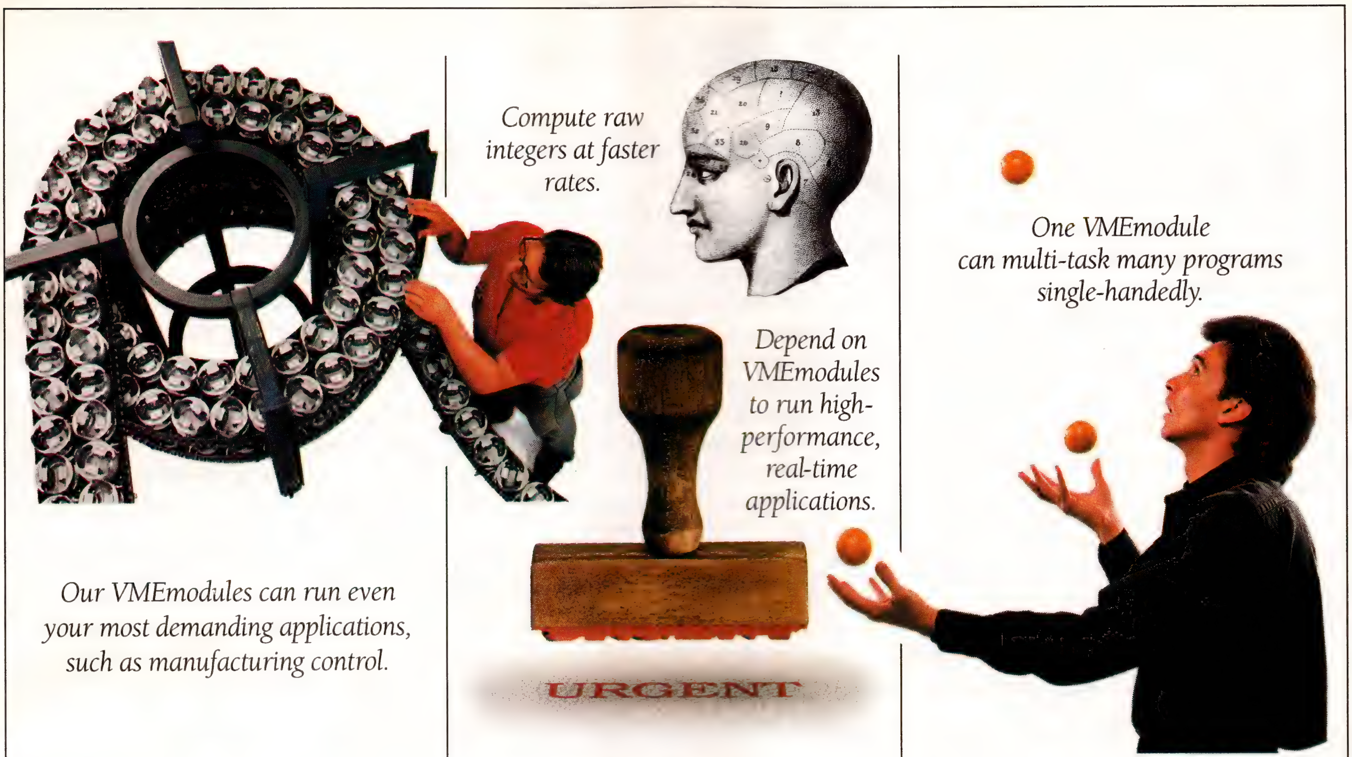
Available now, Spectre HDL costs $10,000 and requires the Spectre simulator ($30,000) to operate. —by Doug Conner

Cadence Design Systems, San Jose, CA. (408) 943-1234.

Circle No. 410



The Spectre HDL system lets you combine VHDL-A, Verilog-A, and Spice descriptions to define and simulate analog and mixed-signal circuits such as this counter-controlled A/D converter.



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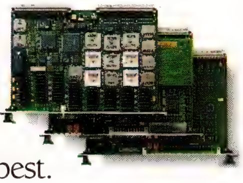

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CIRCLE NO. 71

ETHERNET ICs MIGRATE TO PC MOTHERBOARD

As more and more personal computers get connected to networks, PC manufacturers have begun placing Ethernet interfaces directly on the PC motherboard. IC manufacturers are now making that task easier with highly integrated Ethernet interface ICs.

One recent introduction comes from Cirrus Logic's Crystal Semiconductor Division. The device, the CS8900, has swept together into one IC both analog and memory components as well as the controller logic into a $14.95 (1000), 100-pin device. The CS8900 includes 4 kbytes of RAM for buffering both transmit and receive frames, the analog filters needed for a 10Base-T port, an AUI port, and a direct ISA bus interface. The device also integrates network management counters, Manchester encoder/decoders, LED drivers, and interfaces for boot PROM and configuration EEPROM.

The controller section reduces the need for CPU overhead by automatically processing multiple frames for large file transfers before generating a CPU interrupt. It can also interrupt the CPU before an entire frame is in to allow preprocessing for greater throughput, and can perform DMA transfers to system memory without CPU intervention.

Another entry in the Ethernet motherboard IC market comes from National Semiconductor. The PC87340VUL combines a NE2000-compatible 10Base-T Ethernet controller with all the standard I/O functions of a PC. The device includes UARTs, floppy- and hard-disk controllers, an Enhanced Capabilities Parallel (ECP) port, and a 6-kbyte SRAM buffer.

To ease manufacturing concerns, the 160-pin PC8733VUL offers a pinout that allows designers to overprint the device's pad pattern with that of the smaller 100-pin PC87332 SuperI/O device. The overprint pattern allows designers to create a single board layout that will accept either IC. The device costs $23.50 (10,000).

—by Richard A Quinnell

Cirrus Logic Inc, Fremont, CA. (510) 623-8300. **Circle No. 411**

National Semiconductor Corp, Santa Clara, CA. (408) 721-5000. **Circle No. 412**

Visual tool aids C++ development

A new visual-programming tool and C++ application framework simplifies cross-platform development of object-oriented software. XVT-Architect reduces requirements for writing code by hand and, with point-and-click features, shows the structures of applications and the messaging relationships among objects. You can use the tool to view the class inheritance of objects, and you can set data members (states) to the class-instance level. You can directly access inherited states to simplify your understanding of object usage.

XVT-Architect combines with new features in SVT-Power++ and with Rogue Wave Tools.h++, a standard library of data structures for C++, to form the XVT Development Solution for C++ 3.0. The package is available for Windows, Windows NT, Macintosh, OS/2, OSF/Motif, and Open Look. Licensing costs are $1950 per seat on PCs and $6300 per seat on workstations.

—by Gary Legg

XVT Software Inc, Boulder, CO, (303) 443-4223. **Circle No. 413**

Microwave-design software helps create communications revolution

When EEsof created its Libra and Touchstone CAE tools for design and analysis of microwave circuits, the major market was in defense. Hence the downsizing of the military establishment could have caused the company more than a little anxiety. You can call the situation a case of being in the right place at the right time, but EEsof, now part of Hewlett-Packard, is enjoying burgeoning demand for its products. The reason is that the same sorts of tools that solve high-frequency design problems in military applications are just what the industry needs to solve high-frequency design problems in the explosively growing wireless-communications market. Libra, modified by the addition of RF-element libraries, is now available under the name J-Omega. Other products have made similar transitions.

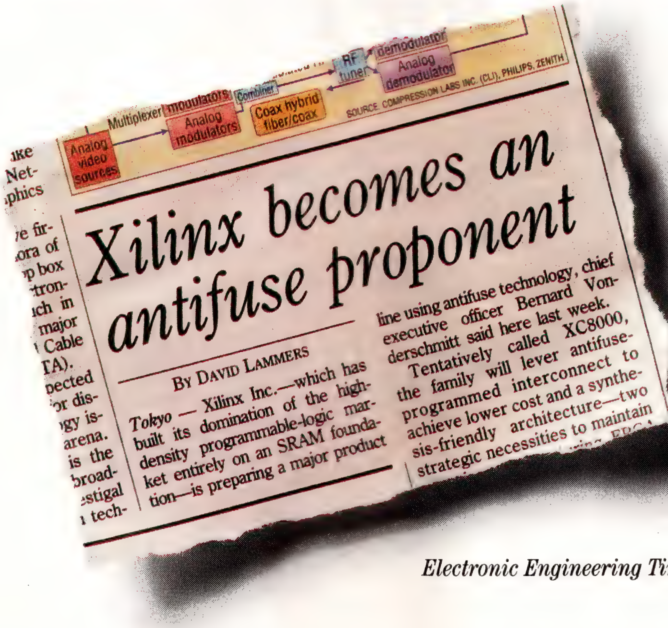
—by Dan Strassberg

HP-EEsof, Westlake Village, CA, (818) 879-6200. **Circle No. 414**

CALENDAR OF UPCOMING EVENTS . . .

Sept 7, 1994	**Electronic Materials Application Show**, Bloomingdale, IL. A one-day show featuring free technical sessions and more than 30 manufacturers. Electrical Insulation Suppliers Inc, 300 N Mannheim Road, Hillside, IL 60162. Phone (708) 547-5400; fax (708) 544-7297.
Sept 8 to 9, 1994	**Unicode Implementers' Workshop 6**. Santa Clara, CA. A two-day workshop covering implementation aspects and case studies. The Unicode Consortium, Box 700519, San Jose, CA 95170. Phone (408) 777-5870; fax (408) 777-5082.
Sept 20 to 23, 1994	**Embedded Systems Conference**. This four-day conference combines more than 100 lectures, workshops, and tutorials with an exhibition of embedded development tools and utilities. Embedded Systems Conference, Santa Clara Convention Center, Santa Clara, CA 95054. Phone (415) 905-2354; fax (415) 905-2220.

We couldn't have said it better ourselves.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Xilinx becomes an antifuse proponent

By David Lammers

Tokyo — Xilinx Inc.—which has built its domination of the high-density programmable-logic market entirely on an SRAM foundation—is preparing a major product line using antifuse technology, chief executive officer Bernard Vonderschmitt said here last week.

Tentatively called XC8000, the family will lever antifuse-programmed interconnect to achieve lower cost and a synthesis-friendly architecture—two strategic necessities to maintain

Electronic Engineering Times, May 23, 1994

Antifuse FPGAs are better than SRAM.

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CIRCLE NO. 80

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Authors are invited to submit abstracts, biographies, and/or completed papers on recent advances, practical design techniques, and case studies in the design of advanced digital systems. Areas of interest include, but are not limited to:

☛**HIGH-PERFORMANCE COMPUTING ARCHITECTURES**
- Multiprocessing
- Reconfigurable hardware
- 100+MHz microprocessors
- ESDA (practical aspects)
- Packaging effects on architecture design
- Memory/cache design

☛ **HIGH-SPEED DATA MOVEMENT**
- High-performance bus design (PCI bus, EISA, VL)
- Using high-speed serial links
- I/O-system design
- Driver/interconnect effects on high-speed data movement
- Timing analysis and verification
- Optimizing mass-storage communication

☛**REAL-WORLD EFFECTS ON DIGITAL SYSTEMS**
- Signal integrity
- Practical pc-board layout techniques
- Electromagnetic interference (EMI)
- Clock distribution
- High-speed packaging effects
- Metastability

☛**HIGH-PERFORMANCE EMBEDDED DESIGN**
- DSP supplanting traditional CPU
- Graphic-system design
- Image processing
- Debugging high-performance embedded systems
- Embedded hardware/software integration
- CASE for embedded system design

SCHEDULE

Abstracts/Biographies Due:	Aug 31, 1994
Acceptance Notification:	Sept 23, 1994
Final Paper Due:	Dec 1, 1994
Conference Dates:	Feb 28 to Mar 2, 1995

Note: Existing papers in the areas of interest should be sent along with the abstracts/biographies.

SUBMISSION INSTRUCTIONS

Send six copies of your abstract, biography, and double-spaced, double-sided existing papers to:

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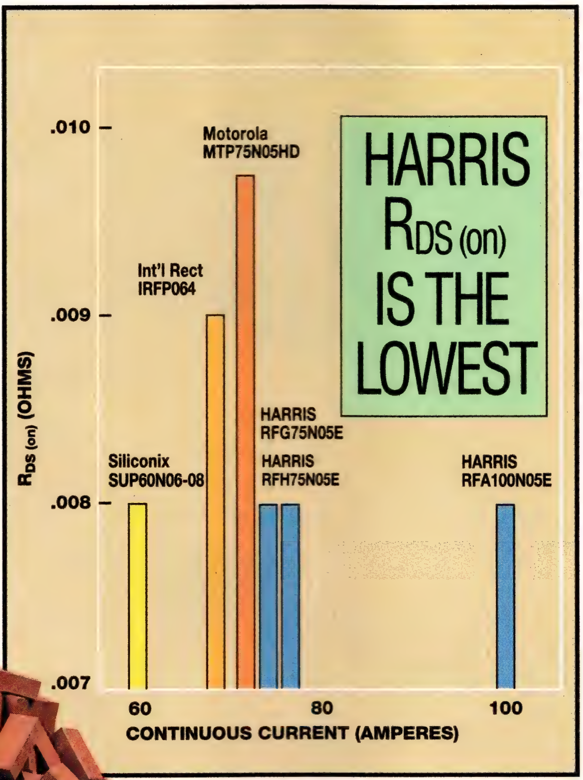

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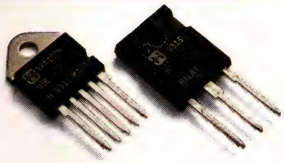

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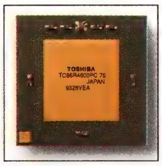


RISC Microprocessor

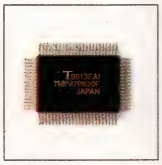
Low Voltage DRAM

Liquid Crystal Display

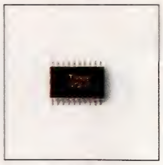
High Speed SRAM

ASIC

Lithium Ion Battery



Microcontroller



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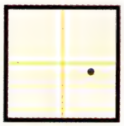
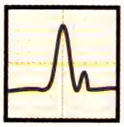
Looking for analog confidence in a digital oscilloscope? Tektronix' TDS 350 sets the standard with Digital Real Time. ■ Its incredible *one gigasample / second* sampling delivers real-life capture like never before — both for single shot or repetitive events. Select peak detect for slow events, or push the scope to its full 200 MHz bandwidth — with no aliasing. ■ And, like the entire TDS 300 family, the TDS 350 sets a new standard in price/performance: under $4,000.



ONE POINT CAPTURED. SINGLE EVENT CAPTURE USING EQUIVALENT TIME SAMPLING. 20 MS/s 100 MHz DSO.



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Analog look and feel. The TDS 300 family is simple and intuitive; just like your trusty analog scope. Even the digital interface is simplified with on-screen icons. You may never have to crack open the instruction manual!

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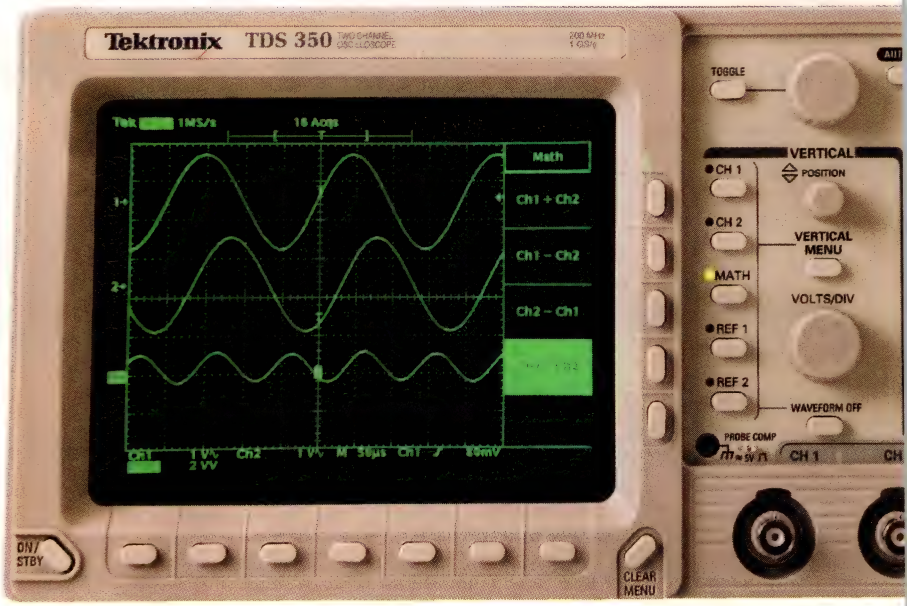

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Channels	2	2	2
Vertical Sensitivity	2 mV - 10 V	2 mV - 10 V	2 mV - 10 V
Vertical Resolution	8 bits	8 bits	8 bits
Record Length	1K/channel	1K/channel	1K/channel
Standard Advanced Features	TV Line & Field Trigger, Roll Mode, Autoset, 21 Automatic Measurements, Peak Detect		
Comm. I/O (Option 14)	GPIB,RS-232, Centronics and VGA video output		
Price	$2295.	$2995.	$3995.

Get real. For more real-time benefits of the TDS 300 family, call your authorized Tektronix distributor today. Or call Tektronix at (800) 426-2200, ext. 212.

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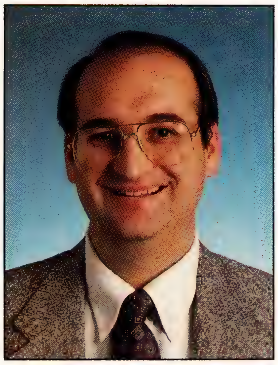

Decades of technology ready to be mined

Fifty years ago, our planet was embroiled in World War II. The political repercussions of that war still ring throughout most of the national power structures of the modern world. Similarly, the technology to fight that war dominated worldwide technological development for decades after the war ended. Much of the development work involved radio and microwave technology that is only now starting to make its way into mass commercial markets. A recent marketing campaign by Motorola's cellular subscribers group reminds us of the link between a World War II soldier's walkie-talkie and today's handheld cellular phones. A photo from that campaign illustrates this editorial.

The Cold War started immediately after World War II and lasted nearly 50 years. As a result, we saw military electronics and computer technology leap ahead at a tremendous pace. For example, the need to put more targeting and guidance electronics into intercontinental ballistic missiles (ICBMs) drove the miniaturization efforts that, in turn, led to intense development of ICs. Currently, the Western world is busily trying to dismantle the ICBMs, but, fortunately, we're still pushing ahead with ICs that are, in a sense, a legacy of the Cold War.

Twenty-five years ago, two men stepped onto the Moon's surface after nearly a decade of intense technological development called the Apollo project. Much of the technology for Apollo involved materials processing and cryogenics, but electronics also played a major role. Commercialization efforts are still mining Apollo's technological developments for more earthbound applications. For example, Apollo's inertial guidance system arose from Cold War work on the Polaris ballistic-missile-guidance system, which itself evolved from the guidance system of Germany's V-2 rocket. In a few years, systems based on successors to missile-guidance systems will appear in consumer automotive applications. In fact, several companies, including Panasonic in Japan, have demonstrated—and, in some cases, fielded—prototype navigation systems based on military hardware, such as ring-laser gyros and the satellite-based global positioning system.

As a global society, we have paid, sometimes dearly, for these technological developments. Therefore, I am pleased and excited to see the growing use of military and aerospace technology for commercial and industrial purposes, all for improving life on earth. In this issue of EDN, we focus on this trend. It's a departure for us, but you'll get a look at how and why companies are using the technology of waging and preventing war to do much more. We hope the stories in this issue will inspire you to do likewise.

Steven H. Leibson

EDITOR-IN-CHIEF

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1990 Certificate, Best Series
1987, 1981 (2), 1978 (2), 1977, 1976, 1975

American Society of Business Press Editors Award
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FLASH

MEMORY SOLUTIONS

Mitsubishi Flash Is

INDUSTRIAL TEMPERATURE & WORDWIDE 1Mb

Mitsubishi 1Mb Flash is in volume production now, for both standard and industrial temperature range (-40 to +85°C) versions and provides power-up/power-down data protection. The Bytewide x8 1Mb Flash is compatible with industry-standard bulk array devices. Mitsubishi industry-leading wordwide x16 1Mb Flash reduces system chip count and is socket-compatible with x16 EPROMs/OTP ROMs.

SMALL BLOCK SIZE 4Mb

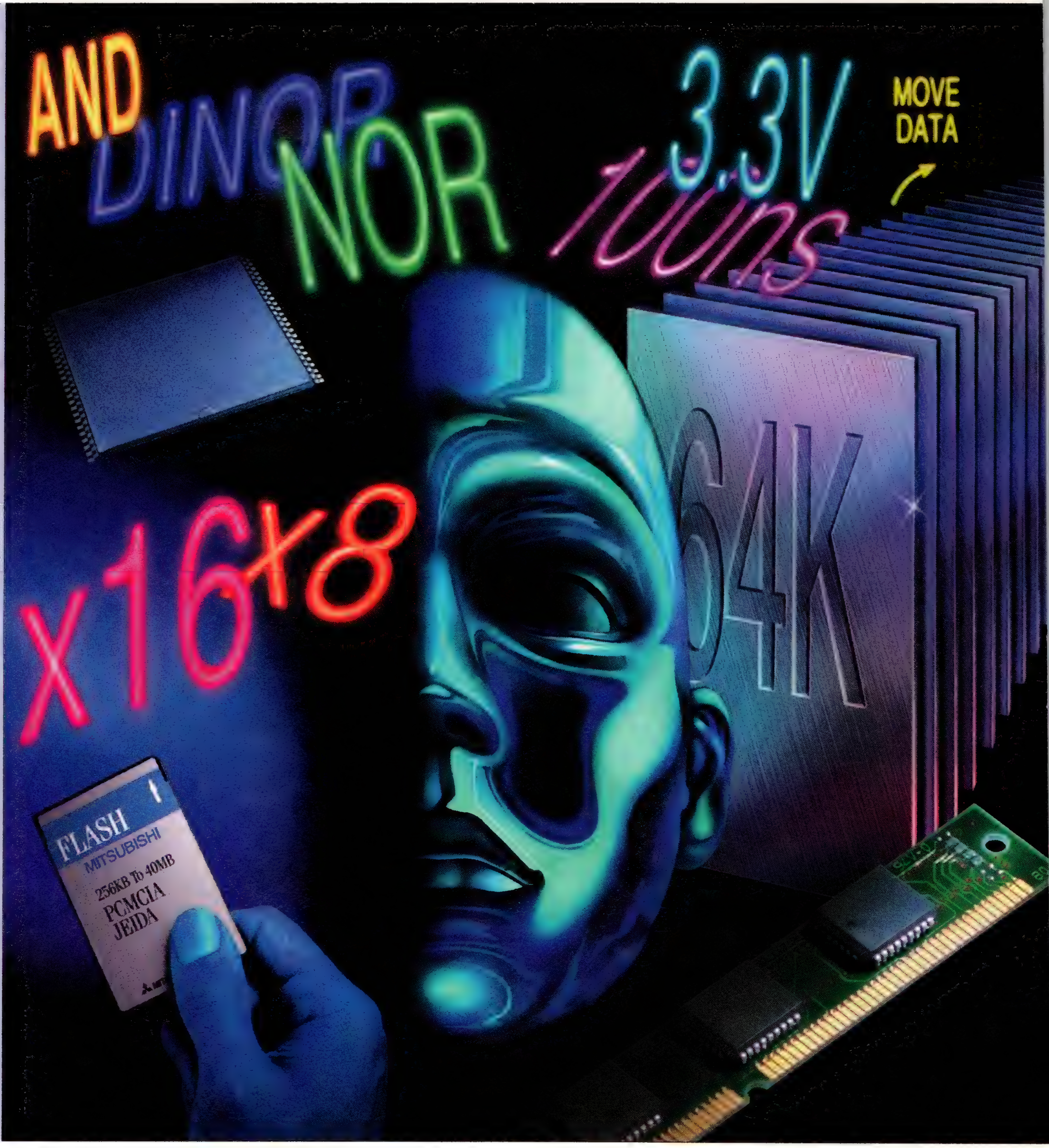
Mitsubishi's 4Mb Flash offers a user-selectable, 512K x 8 or 256K x 16, architecture and small block size: 32 blocks 16KB each for x8, 8K words each for x16, allowing finer granularity for code updates. An automatic program/erase feature enhances overall system performance by freeing the system CPU to perform other tasks and eliminates the need for update software timers.

EASY UPGRADE TO 16Mb FROM EXISTING 8Mb

Designers can easily upgrade existing 8Mb Flash designs to 16Mb without the need for a total system redesign, with the added benefits of faster access time (100ns) at 3.3V and deep power down mode. Mitsubishi's 0.5μm 16Mb Flash offers 32 symmetrical 64KB blocks and comes in an industry-standard 44-pin SOP and a 48-pin TSOP that is pad compatible with industry-standard 40-pin TSOPs.

FLASH CARDS AND MODULES

Mitsubishi PCMCIA- and JEIDA-standard Flash cards come in densities up to 40MB. Standard Flash modules come in 512K x 16, and 512K x 32 organizations. Custom Flash cards and modules can be produced to meet customer-specific needs.



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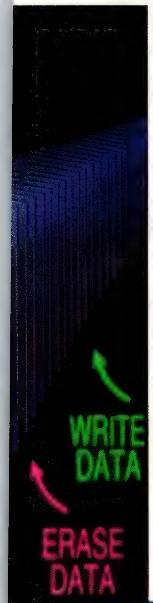
ELECTRONIC DEVICE GROUP

Rewriting The Future.



Amid all the speculation about Flash there are critical questions: What is the best standard? Who has enough capacity? Will Flash replace DRAMs? What about second sourcing? Who has wordwide devices?

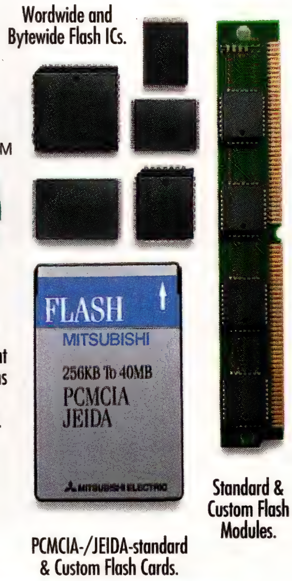
One thing however is certain: Mitsubishi Flash is rewriting the future. We're doing it by offering a wide selection of NOR Flash devices: Wordwide and Bytewide Flash ICs from 1 to 16Mb, PCMCIA-/JEIDA-standard and custom Flash cards up to 40MB, and standard and custom Flash modules.

We're also rewriting the future of Flash via a joint technology development agreement with Hitachi. Mitsubishi and Hitachi will co-develop 16Mb DINOR (Divided Bit-Line NOR) and 64Mb AND devices, setting the de facto, single-voltage (3.3V) industry standard for future Flash. Plus, the Mitsubishi 16Mb Flash you design in today will be pin compatible with, and upgradeable to the future 16Mb DINOR device.

Mitsubishi Flash memories are manufactured at our own wafer fab facilities with deep submicron process technology in place to produce our 0.5μm 16Mb Flash. Advanced technology partnerships with SGS-Thomson and Hitachi help assure your second source and future Flash needs.

TM

Mitsubishi Electric's Symbol of Commitment to Developing Solutions For Semiconductor Environmental Issues.


Wordwide and Bytewide Flash ICs.
FLASH
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256KB To 40MB
PCMCIA
JEIDA
MITSUBISHI ELECTRIC
Standard & Custom Flash Modules.
PCMCIA-/JEIDA-standard & Custom Flash Cards.

DENSITY	ARCHITECTURE	BLOCK STRUCTURE	VOLTAGE READ/ PROGRAM/ERASE	ACCESS TIMES	PACKAGES	BLOCK ENDURANCE MIN./TYP.	FEATURES/BENEFITS
1Mb	128K x 8	Bulk Array	5V/12V_{pp}	100, 120, 150	DIP, PLCC, SOP, TSOP	10K/100K	High Volume Production Capacity; Ind. Temp. Range (150ns); Power-Up/Power-Down Data Protection
1Mb	64K x 16	Bulk Array	5V/12V_{pp}	100, 120, 150	SOP, PLCC, TSOP	10K/100K	Wordwide Architecture Reduces Chip Count; Socket Compatible With x16 EPROMs/OTP ROMs; Industrial Temp. Range (150ns)
4Mb	512K x 8 / 256K x 16 (User Selectable)	32 Sym. Blocks, 16KB/8K Word each	5V/12V_{pp}	100, 120, 150	SOP, TSOP	10K	Small Block Size Optimized for Code/Data Storage Applications; Automatic Program/Erase
16Mb	2M x 8	32 Sym. Blocks, 64KB each	3.3V/12V_{pp}	100, 120, 150	SOP, TSOP	10K/100K	Easy Upgrade from Industry-Standard 8MB Flash Designs; 100ns Access Time at 3.3V; Deep Power Down (0.5μA); Automatic Program/Erase
Flash Cards	256KB to 40MB	-	5V/12V_{pp}	200, 250	PCMCIA/JEIDA	10K/100K	Custom Cards Available; FFS-Type with Memory Technology Driver Software Support
Flash Modules	512K x 16 512K x 32	-	5V/12V_{pp}	100, 120, 150	80-PIN SIMM	10K	Automatic Program/Erase; Custom Modules Also Available

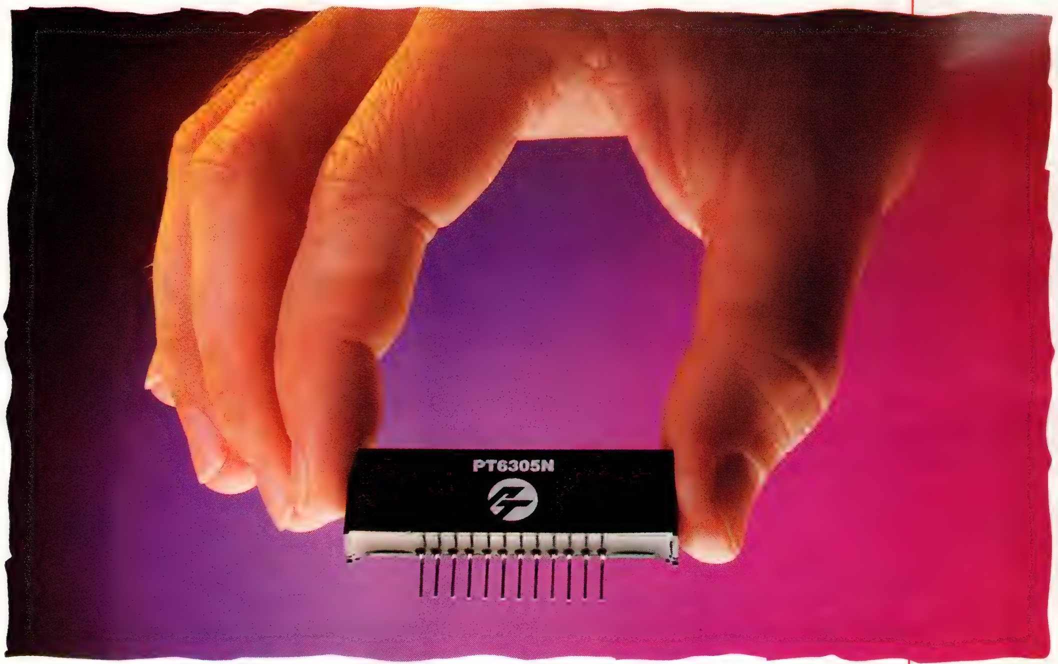
In addition to rewriting the future of Flash, Mitsubishi Electric Corporation is committed to "sustainable development." To this end, the company has eliminated CFCs, including 1,1,1-trichloroethane solvent and carbon tetrachloride in manufacturing processes at all semiconductor production facilities. The company is committed to reducing industrial wastes by 30% in 1995, cutting energy consumed in semiconductor production processes by 25% by the year 2000, and is conducting R & D in recyclable packaging, as well as in solar power energy sources.

For more information on Mitsubishi Flash memories, and details on environmental policies and activities, call **1-(800)-785-0004, Ext. B** or 408-730-5900 Ext. 2106.

CIRCLE NO. 32

MITSUBISHI

SINGLE-DEVICE 5V TO 3.3V POWER



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Now, from the innovator in integrated switching regulators, comes a new series of high-performance 5V to 3.3V, 3 Amp, 12-Pin, single in-line products.

The new Power Trends PT6305 family lets you easily solve the problem of integrating low power 3.3V logic integrated circuits into existing 5V systems, ***without redesigning the power supply.***

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CIRCLE NO. 92

Corrections and additions

In the *EDN* Special Report, "To multiprocess or *not* to multiprocess?" (June 23, 1994, pg 64), we inadvertently printed an incorrect phone number for Sonitech International (Wellesley, MA) on pg 70. The correct number should be (617) 235-6824. Please make a note.

In the *EDN* Special Report, "Power ICs: Weighing the benefits of integration," (July 7, 1994, pg 68), Cherry Semiconductor was left out of the manufacturers contact list on pg 80. The company has an extensive line of power-conversion and automotive ICs, including linear and switching regulators; PWM controllers; motor drivers/controllers; and ignition, solenoid, and relay drivers. The author apologizes for the oversight.

Contact Cherry Semiconductor at 2000 South County Trail, East Greenwich, RI 02818, phone (401) 885-3600, fax (401) 885-5786.

Ship Star takes a stance

I would like to compliment Brian Kerridge on his concise, balanced, and informative article about fieldbus in the April 28 issue of *EDN* (pg 45). However, a clarification of Ship Star's position is in order.

Ship Star Associates claims that its Fchips, interface boards, and tool and product software support both ISP and WorldFIP. This claim is easily verified in the public arena.

- Our Fboard-1, which uses our Fchip-0 (an Actel 1020 FPGA), was a part of both the ISP and WorldFIP fieldbus demonstrations at the ISA93 and Jemima93 trade shows. Our bus analyzer and simulator are in use at the Monsanto Chocolate Bayou ISP field trial. Both our ISP and WorldFIP tools will be used at the BP field trial in Sunbury, UK, and the Esso field trial in Slogan, Norway.
- At our public seminars and tradeshow booth, we frequently demonstrate the ability to run ISP and WorldFIP on the same board and chip by reloading software.
- Our tools are in use by half of the ISP Executive Committee members and a similar fraction of WorldFIP NA board members.
- Our Fchip-1 (a 0.8-μm CMOS gate-array ASIC from AMI) is available in sample quantities.
- Ship Star's ability to use the same (existing) chips and boards and to draw working code from both protocol stacks promises our users an easier (software-only) upgrade path if a merger of fieldbus protocols occurs or if long-term support of both protocols is required.

In addition to our position as the only independent American developer and supplier of fieldbus technology, Ship Star is committed to supporting process control and automation suppliers as they introduce fieldbus in a timely and cost-effective manner. We will not compete with their products.

Robert Crowder, President
Ship Star Associates Inc
Newark, DE

Get results, not lip service

Your great editorial (*EDN*, July 7, 1994, pg 33) reminded me of a problem I had with one of our nation's largest mainframe computer manufacturers (DEC) a number of years ago.

When our lead engineer gave up on trying to solve the problem, I decided to take some action on my own as system engineer on the program. I wrote a letter directly to the president of the company outlining the difficulties we had experienced—and demanding that the company solve the problem.

Within a week, five experts visited us on site to discuss our problem—and took pains to solve it. When a month passed without action, I wrote another letter to the president of the company and got the problem solved. So your advice worked for me: Don't take it any more—act!

Allan C Stover
Westinghouse Electric Corp
Cockeysville, MD

Demand EDA excellence

I am in complete disagreement with John Cooley's implication that the market cannot simultaneously support quality and competition on the commodity level ("CFI? The shape of things to come?" *EDN*, June 23, 1994, pg 141). Has Mr Cooley ever noticed that some of the highest quality products are commodity—or compete directly with commodity product, and that the well-managed manufacturers of these commodity products make

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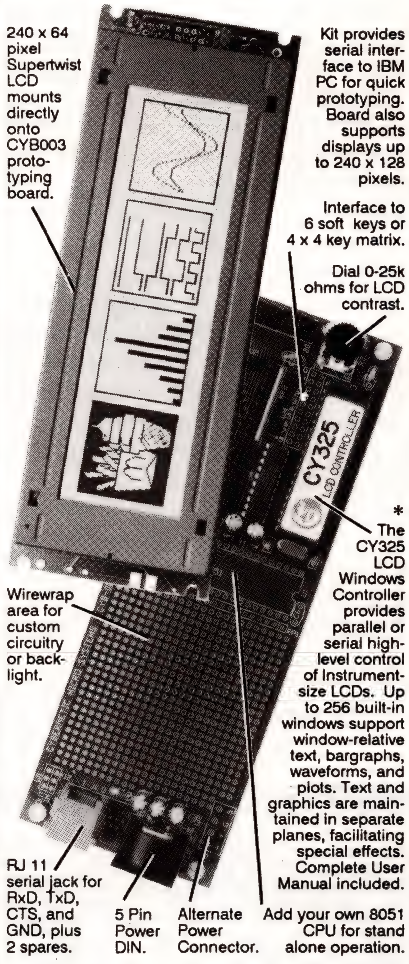
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CIRCLE NO. 94

sound profits year in and year out?

The lack of adequate competition in the EDA industry leads to bizarre and counterproductive policies by established vendors. Take, for example, the foolishness of Viewlogic's PC-based products:

Viewlogic produces a promising product for Windows called Pro Series. This product is light-years ahead of the old Windows-hostile Workview 4.1 and its successor, Workview Plus. Yet, Viewlogic has taken pains to prevent its customers from purchasing this product and using it with existing databases. I get it: First I bought your old product, funding your R&D; then I bought your new, superior product that you developed with the profits. But am I not supposed to use the better product with my existing databases?...Right!

What customer interest is served by this insane policy? Would anyone buy a word processor that could not read documents made with a previous version? Why should EDA software be different? Nonsense like this exists because the user community extends exactly the kind of tolerance Cooley advocates. Such tolerance doesn't finance better products. It subsidizes poor ones.

Complacency with ourselves or our business partners breeds failure for all. Strive for, demand, and deliver excellence.

Steve Weir
Harris Digital Telephone Systems Division
Novato, CA

High-tech hassles

Despite a partly illegible ticket and an incorrect vehicle identification ("Technological proof of innocence: Part 1," *EDN*, May 26, 1994, pg 45), of course you are "guilty." Guilty, that is, of challenging a municipal revenue-generating scheme that operates in contempt of the public. Bar-coded license plates cannot eliminate error or expose fraud, but may well make revealing and correcting these abuses impossible. Government functionaries embrace the aura of infallibility their procedures, forms, and computer printouts offer. Why make a bad situation worse?

Instead, let's get rid of high-tech legal appliances *now*, before it's too late. Determination of guilt must remain a human-judgment call, subject to a second opinion (appeal)—not the verdict of a gadget. The de facto "guilty until proven innocent" of traffic court is despicable. Should across-the-board justice become the stepchild of efficiency, the result would be incredibly tragic.

Don Mennie, Technical Writer
Mendham, NJ

More comments on CEBus commentary

I am responding to Steven J Ackerman's letter (*Signals & Noise*, June 23, 1994, pg 21). Ackerman suggests that CEBus (consumer electronics bus) is a potential fieldbus alternative. He also questions the prices of LonWorks products cited in the article (*EDN*, April 28, 1994, pg 45). While Mr Ackerman's company is not exactly disinterested—he manufactures CEBus products—neither is Pensar: We are a $40-million product-development and manufacturing company serving OEM customers in the industri-

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al and medical marketplace and have designed and manufactured LonWorks products for a number of customers.

The reasons CEBus falls far short of providing an industrial-strength fieldbus are contained in Ackerman's letter. He notes that CEBus provides a streamlined five-layer version of the ISO/OSI seven-layer model. (CEBus actually provides services only at four layers.) The lack of the full seven layers increases application complexity and thus the chance of implementation error. Moreover, it means that the structure to provide interoperability among products from different manufacturers doesn't exist. It's for these reasons that ISO specified all seven layers.

Ackerman also notes that "CEBus is easily incorporated into systems with low-cost 8-bit microprocessors." While superficially appealing, the statement does not take into account that such μPs do not have the processing power to handle many fieldbus applications in addition to the CEBus protocol. Therefore, either a more expensive processor or a second one would be necessary for many nodes.

In addition, Ackerman says that CEBus is an open standard. It may be, but it still requires you to use a patented power-line technology from a sole supplier. He also states that "implementing CEBus devices is easy with a low-cost development system that generates code from your specs." Developers of fieldbus applications need a variety of tools, including compilers, debuggers, emulators, network managers, and protocol analyzers. Without these, development will be anything but easy. In addition, assembling them piecemeal into a complete development environment will be anything but low-cost.

As Ackerman notes, CEBus is a creature of the Electronic Industries Association, the consumer electronics group. It is intended primarily for consumer devices in the home, and its exclusion from balanced pieces on industrial fieldbus options is wholly understandable.

In describing his view of CEBus' merits, Ackerman presents an inaccurate and unfair picture of LonWorks technology. He speaks of the high cost of royalties for LonWorks. We have produced thousands of application devices incorporating Neuron ICs and LonWorks transceivers. These devices have not been subject to royalty payment of any kind. He also states that CEBus provides support for fiber-optic communications. To the best of my knowledge, that specification has yet to be finalized.

Last, he speaks of a high-cost development system. We consider the acquisition cost of development tools in the broader context of overall cost when evaluating tools for the design, deployment, and maintenance of control networks. From this perspective, the LonWorks development suite has clearly proven its value. A comparison with the CEBus development environment is not valid.

Richard V Baxter Jr,
VP/Chief Technical Officer
Pensar Corp
Appleton, WI

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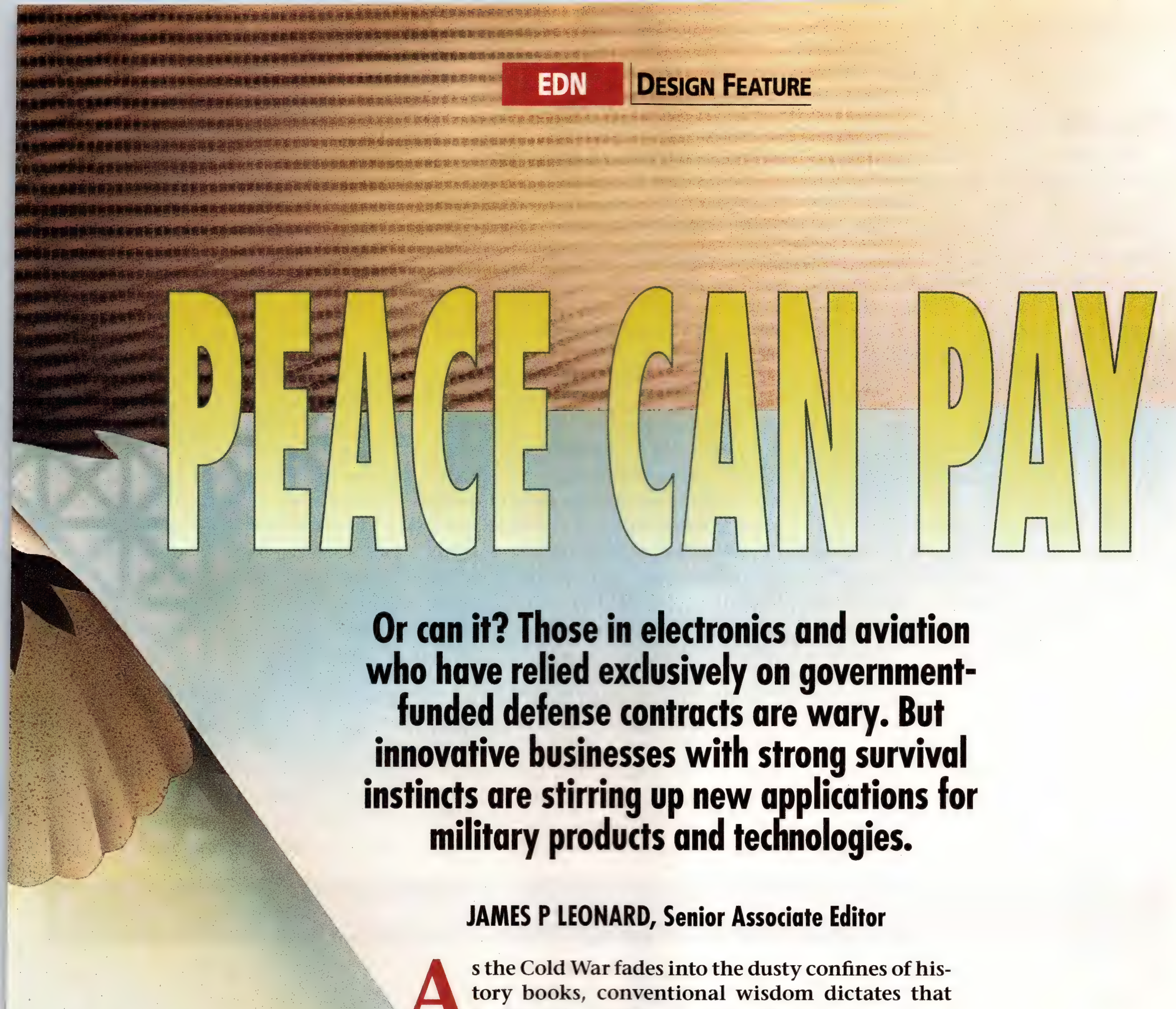

PEACE CAN PAY

Or can it? Those in electronics and aviation who have relied exclusively on government-funded defense contracts are wary. But innovative businesses with strong survival instincts are stirring up new applications for military products and technologies.

JAMES P LEONARD, Senior Associate Editor

As the Cold War fades into the dusty confines of history books, conventional wisdom dictates that budgets for defense- and military-related electronics contracts will steadily decline into the early part of the next century. With government-contract work radically scaled back and defense budgets slashed, electronics and computer companies are forced to scrutinize and redirect R&D and manufacturing dollars.

Redeployment efforts focus on identifying markets that fit existing or emerging technologies into civilian-use applications. Like most ventures, however, the road to successful conversion of defense-related business to nonmilitary markets can be riddled with mines—and rife with potential.

By 1997, the Department of Defense (DoD) predicts its spending will shrink to 3.6% of the US GDP (gross domestic product), down from 6.5% under the Reagan administration. The DoD's 1997 budget goal marks the lowest level of defense spending relative to national income since the end of World War II.

Private-sector defense-related jobs are expected to decline to 2.3 million by 1997, down from 3.2 million in 1991. Not surprisingly, the bulk of jobs lost will be in the manufacturing sector. See **Table 1** for a breakdown of states most reliant on government funding—and thus hit hardest. Note the numbers for California.

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PEACE CAN PAY

The consequences of a continuous decline in military-based spending are manifold. In Southern California, for example, defense cutbacks dent more than just company profits and market strategies; coupled with a relentless recession, continual layoffs burden local economies, which in turn drain state and federal unemployment and social-service allocations.

California's economy is a symptomatic, albeit extreme, example of an economic downward spiral throughout the United States. Worldwide recession, increasing manufacturing competition from the Pacific Rim, and domestic-government cutbacks challenge, and often cripple, the competitiveness of local business. Other belt-tightening moves—Congress-mandated military-base closings; decreased technology investment and research; and deferred infrastructure improvements, for example—collectively take their toll on the local economy.

The US departments of Commerce and Defense corroborate: They report a projected loss of approximately 605,000 professional and 597,000 "precision-production" defense-related jobs in the private sector by 1997. In late June, the US Congress announced mandates to slash defense-related university and scientific research by at least 60% for next fiscal year. The Massachusetts Institute of Technology (MIT) alone stands to lose more than $1 million in research grants.

Any business that relies heavily on military contracts has to rethink how executives, managers, and workers do business from the ground up. Fortunately, change and uncertainty can work to your advantage by drumming up new ideas for product manufacturing and marketing. "In order to survive, we must create new work," says ESL President Art Money, chair of the Defense/Space Consortium (DSC) in Silicon Valley.

The big picture isn't all grim

Companies are rapidly gearing up for change, and the federal government has actively spurred the transition to civilian-based work. The federal Technology Reinvestment Project (TRP) implements the Small Business Innovative Research (SBIR) program as well as eight statutory programs. Congressional funding for the TRP exceeded $471.6 million in 1993 (projections for next year approach $600 million).

The TRP assists companies that create products and process technologies that directly suit both defense and commercial applications. In addition, the program sponsors manufacturing education and training programs that strengthen workers' skills and, in the long run, improve US industrial competitiveness. In its first year, the initiative reviewed close to 3000 proposals from companies willing to invest in this project.

Government funding is one source of help for initial investment. Yet federal regulations and international trade quotas are hardly enough to save defense-dependent industrial giants. Southern California is a poignant example. Facing the demise of billion-dollar government contracts, Northrop, Rockwell International, Hughes, McDonnell Douglas, and their extensive network of military-based suppliers and distributors are begin-

DEFENSE CONVERSION AND DIPLOMACY

At Boston University, educators, scientific researchers, and engineers have teamed with overseas counterparts to implement post-Cold War applications for wartime technologies. The Defense Technology Conversion Center seeks to convert defense-based industry to market-driven civilian and commercial production. The group's charter is to join industry, government, and academic institutions to promote applications and markets for defense-conversion projects. The Center also strives to retrain, educate, and cultivate a skilled work force from the growing number of displaced or redundant defense workers.

The Defense Technology Conversion Center has sponsored joint partnerships involving scientists from Russia and the United States, first in Boston in 1992 and, in the last two years, in Moscow and St Petersburg. The goal of these meetings was to motivate researchers to convert major segments of high-tech weapon R&D and production into viable civilian and commercial enterprises. The group has focused on peacetime activities in the former Soviet Union because of political disintegration and instability, particularly in republics such as Ukraine where a bulk of Soviet nuclear capability remains.

The Center essentially targets defense-related research and enterprises in the United States, The Commonwealth of Independent States, and China. It instructs and disseminates information via workshops, symposia, and project-design collaboratives. Manufacturing partners include GTE, Hewlett-Packard, Litton/ITEK, Raytheon, and Teradyne in the United States; BeLomo, Integral, and Minsk Computer in Belarus; and Almaz, Leninets, and NPO Mashinostroenia in Russia. US financial and research partners include Fidelity Investments, Batterymarch Financial Management, Palmer Service Company, American International Health Alliance, Arthur D Little, and Cannon Associates.

The Defense Technology Conversion Center draws its academic representatives from Brown University's Center for Foreign Policy Development, Harvard University's Center for Science and Public Policy and Russian Research Center, and the Massachusetts Institute of Technology's Enterprise Forum and Nuclear Engineering Department. In addition, the Center collaborates with the US Arms Control and Disarmament Agency (ACDA), the Agency for International Development (USAID), the Department of Energy, and the DoD.

For more information, write the Defense Technology Conversion Center at Boston University, 143 Bay State Road, Boston, MA 02215. Phone Director Clark Abt at (617) 353-5118 or fax (617) 353-2243.

ning to evolve and diversify both within and without their respective industries. Some are scrambling to find business in commercial sectors.

The biggest challenge for these giants, however, may be the task of converting their own company cultures. Moving from specialized "MIL-STD mentality" to more efficient, proactive, and nonproprietary modes of business can be a tough task. A company culture custom-tailored for government-contract work must yield to a different mindset if innovation and change are to succeed on a large scale.

Government initiatives (and millions in federal allocations) will be wasted if companies fail to secure real, long-term markets for their military-based production systems. Critics voice concern that these efforts are useless and that defense monoliths face imminent extinction in the next decade.

Fortunately, innovative efforts are working for some companies: By experimenting with new technology in applications previously too costly or impractical to implement, companies are beginning to turn a profit. The success of wireless television networks is one such example. This industry has a viable future because, for a few hundred dollars, consumers can now buy a small satellite dish to connect into the system. Another alternative is to customize commercial products and expand their environmental performance without altering schematics. By doing so, you can market previously commercial-only equipment to the US military.

So-called "dual-use" products and technology are cost-effective and efficient to produce. At Raytheon, for instance, Beech Aircraft is producing commercial and military aircraft from the same structural design; even better, the military jets roll off the same assembly line as their commercial counterparts. To accommodate MIL-STD specs, engineers custom-designed the production process to outfit the military aircraft throughout various stages of assembly (turn to pg 56 for more on Raytheon's conversion business).

Dual-use manufacturing takes a cue from businesses that have deliberately (and successfully) marketed products to both civilian and military uses.

Selling COTS (commercial off-the-shelf) components and ruggedized computers to the military evolved from a budget directive that sought to cut R&D time and money in half for many military contracts. Because a MIL-STD computer system, for example, may cost up to 5 times that of a commercial (nonruggedized) system, opting for COTS hardware could save the military millions annually. Manufacturing and marketing COTS products can be a tricky business, but with a bit of creative upgrading to ruggedize commercial components, companies such as Codar Technology Inc (Longmont, CO) simultaneously target both military and civilian markets.

FOR MORE INFORMATION...

For inquiries on the Technology Reinvestment Project (TRP), a joint program of the US DoD and Department of Commerce, phone (800) DUAL-USE or (703) 696-8942.

For a bibliography of more than 50 reports, books, article citations, and publications related to defense conversion, contact the OECI (US Office of Economic Conversion Information) by phone at (800) 345-1222 or modem at (800) 352-2949. If you have a fax machine, the OECI's phone line will switch over to a fax-request line: Using a touch-tone phone, select the library index from the main menu, then switch the line to your fax. The listing will arrive in seconds.

To learn more about the Silicon Valley Defense/Space Consortium (DSC), contact Jim Ewan at (415) 960-8601 or Eric Rosenfeld at (408) 271-7215; phone Tim Quigley, executive director of the defense-based consortium, at (408) 562-6022; or reach Doug Henton, network manager, at JVSVN (Joint Venture: Silicon Valley Network), 111 Almaden Blvd, Eighth floor, San Jose, CA 95113, phone (408) 271-7213.

Rethink business

Going beyond traditional conversion techniques, businesses once thought to have little in common are joining in shared research projects and long-term market planning, especially among competitors. And, in regions already home to interrelated industries, communication networks offer to grow new markets—and help convert existing ones. Silicon Valley, for instance, is rebounding. Companies are forming consortia and information networks, embracing alternative manufacturing methods, and creating markets that target remaining defense-related contracts and new consumer applications.

The Silicon Valley Defense/Space Consortium (DSC) is an alliance of business, government, and community leaders set to improving Silicon Valley's economic competitiveness. The DSC offers companies assistance in identifying partners and forming alliances; guidance and support in obtaining matching funds for dual-use and commercial-military partnerships; and conferences and workshops in areas such as marketing, commercial-product development, organizational change, and forming other strategic alliances.

The Consortium's charter sets forth a model for business success that seeks to grow a strong and diverse economic/industrial base for the region by uniting talent from local government, industry, and education. Objectives include

- Developing a specialized infrastructure, using efforts such as technology collaboration among companies—and between business and university leaders
- Reducing the cost of conducting business by initiating dialogue between public- and private-sector leaders to work for common ground in tax rates, short- and long-term fiscal planning, and local regulatory procedures
- Retaining and expanding existing industry by promoting specialized focus groups to air grievances and brainstorm; reaching consensus on regional goals by involving a range of interrelated businesses
- Attracting new industry, such as environmental consulting, software, and entrepreneurial pursuits.

DSC has functioned as a catalyst for forming technology partnerships; to date, the alliance assisted in chartering an array of programs, including The Northern California Healthcare Alliance, which used advanced network and communication technologies to form a regionally based health-care information system. Securing the final product involved Sun Microsystems, Andersen Consulting, NASA-Ames Research Center, Pacific Bell, Space Applications Corp, and Seton Medical Center.

Last year, the Wireless Communications Alliance formed to share and develop applications for the expanding wireless market; this partnership involves ESL, Intel, Siemens, Teledyne Microwave, Trimble Navigation, Watkins-Johnson, and Wyse Communications. The DSC-sponsored endeavors prove that corporate and industrial diversity can link successfully.

Real-world applications

In the ever-expanding wireless-communications world, commercializing the global positioning system (GPS), a DoD-commissioned technology program called NAVSTAR, opens a host of applications for a former military-specific technology. GPS, which is a radio-navigation system that employs RF transmitters in 25 satellites, uses receivers to decode satellite signals and calculate latitude, longitude, and altitude of points on Earth.

Commercial applications range from surveying and navigation equipment to airplanes and trucks. GPS's accuracy improves ground-based radio-navigation accuracy by 10 to 100 times. Military-specific companies working with GPS technology include ITT Defense, GEC-Marconi Defense Systems, Alpha Products, and Honeywell. But geologists and weather forecasters, oil conglomerates, and rental-car companies are some of the myriad civilian-use buyers of this technology.

Rental cars, for example, are a testbed for GPS-related tracking of the optimal route for point-to-point travel. Small on-dash color displays provide directions and digital maps for business travelers or drivers unfamiliar with local geography or interstate routes. CD-ROM makes data storage and retrieval practical and economical for such large-scale applications. Thus, GPS creates a commercial market and sparks a demand for mass-market software as well as the hardware needed to access it.

Because GPS still has an integral role in future military-based applications, it bridges commercial, military, and scientific-research applications. One detractor, however, is that commercial proliferation of GPS-based products must rely on military control and regulation of satellites, which involves US taxpayers (annual costs for the GPS exceed $500 million).

Other wireless applications that incorporate microwave, infrared (IR), and RF technology include mobile computing for offices, businesses, warehouses, and universities. To date, the lack of interoperability among and between products has been a major drawback; because vendors have not invested enough time, effort, and money into improving compatibility, the market, as a whole, has suffered.

DEC is currently working to co-develop base wireless LANs from existing AT&T systems; Motorola's MNI (Mobile Network Integration) makes Motorola's products more interoperable and improves compatibility with other wireless systems and services.

Interoperability is clearly an investment in the future: Economic forecasters expect the US market for wireless LANs to grow from its current $36 million to $350 million by the end of the decade—and more than $500 million worldwide. Moreover, in November of last year, the IEEE approved the 802.11 MAC protocol. With some modification, IEEE 802.11 will become a worldwide standard for wireless LANs and protocols.

New revenue bases

Other areas of new-market growth for military technology stem from mass data storage and retrieval, security, and multimedia. High-capacity data storage unites media, software, and hardware. Financial, medical, scientific, and automotive markets, for example, depend on efficient and economical access to large chunks of data—from tens of gigabytes to thousands of terabytes—just to conduct day-to-day business.

For more than a decade, Dallas-based

TABLE 1—STATES AFFECTED BY DEFENSE-RELATED ECONOMICS

	CA	CT	FL	MA	MD	MS	NJ	NY	OH	PA	TX	VA
US-government consumption of total goods/services (%)	18.5	3.4	3.9	4.7	N/S	N/S	3.0	6.3	4.2	3.8	6.6	4.5
Private-sector defense-related jobs (% of total state workforce)	18.0	3.5	4.1	4.9	N/S	N/S	3.2	6.7	3.9	3.8	6.2	5.1
Direct defense-related employment (>5% of private-sector jobs)	5.6	8.3	N/A	6.5	5.5	5.2	N/A	N/A	N/A	N/A	N/A	7.4

Note: N/S = not specified; N/A = not applicable.

Data courtesy of US Department of Commerce and Department of Defense.

ILLUSTRATION / DANIEL GUIDERA

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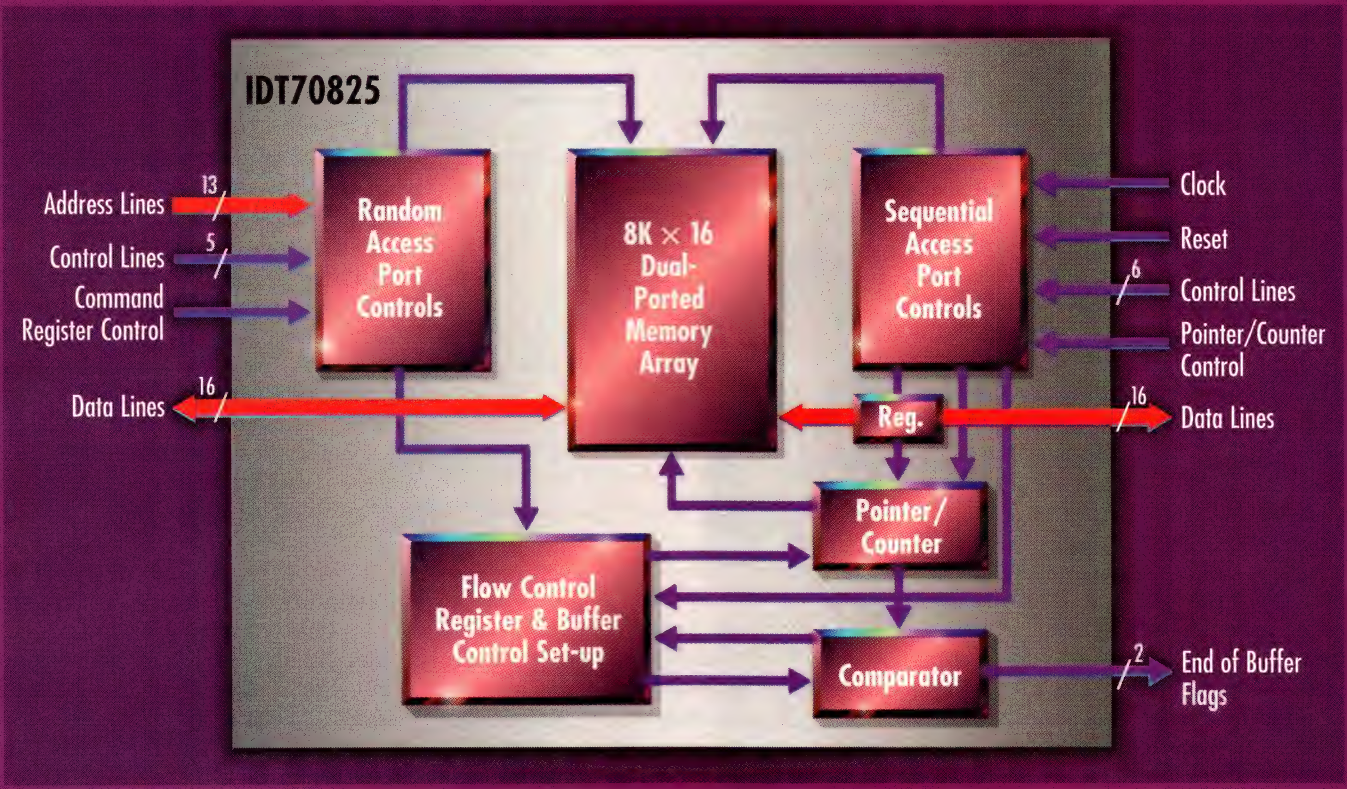

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EMass Storage System Solutions has been involved with data-storage products for government-contract work, such as intelligence, reconnaissance and surveillance, command and control, and aircraft maintenance and modification. The company's strategy for research, production, and marketing now includes targeting scientific and technical, financial services, medical, seismic and weather, broadcast media, insurance, and educational applications of data capture and storage.

Security is—and will continue to be—an explosive market opportunity, especially as information and communication networks proliferate and become increasingly easy to access. A rash of Internet break-ins in late spring proved a painful and costly reminder of LAN/WAN system vulnerability. Software manufacturers, their customers, and even the federal government suffer financially and proprietarily from security breaches.

Economists in the electronics and computer industries expect multimedia to take off toward the end of the decade. Although multimedia did not grow specifically from military technology, many dual-use and former defense-related companies are turning to multimedia for new sources of revenue. Multimedia applications have almost universal appeal: Executives traveling in various time zones or located on different continents can arrange teleconferences, video conferences, or pen-based on-screen brainstorming sessions. Initial equipment costs can be prohibitive, but conducting a transcontinental teleconference may cost a lot less than air travel.

In the last three or four years, many computer companies allied with media and publishing companies and electronics companies to exploit new educational and entertainment markets. Successful applications include virtual reality and personal handheld communication devices.

Personal communicators continue to decrease in size and cost. In late June, Motorola introduced the Envoy, a personal-communications device that sells for around $1500. Using Envoy, you can receive faxes and e-mail and shop electronically via on-line catalogs.

Another commercially viable technology is the Digital Satellite System, a satellite-TV system. For just under $700, consumers can buy an 18-in. satellite dish to hook into a new form of TV that promises to compete with cable. DSS offers 175 new channels. This commercial system results from a joint venture linking Hubbard Broadcasting, Hughes Aircraft, RCA, and General Motors.

Virtual reality is a prime example of dual-use technology: To train fighter pilots, the military uses virtual reality for in-flight simulation; civilian markets continue to expand into interactive-television and video-game applications. Automakers are experimenting with virtual-reality head-up car displays. Odometer, speedometer, and gas-gauge readings project onto a car windshield, eliminating the need for drivers to take their eyes off the road to check instrument readings.

The foundation of the 21st-century "Information Age" may prove that a free flow of proprietary information doesn't hinder profitability but ensures it.

In addition, because multimedia involves a diverse range of hardware and software products and has grown-up in the '90s, its applications are increasingly security-conscious. Multimedia tools available today let you distribute tamperproof executable files that incorporate sound, animation, text, schematics, and other relevant data.

Multimedia has two main drawbacks: initial equipment investment and lack of integration among infrastructure, tools, and applications. In an attempt to address these issues, IBM joined with Sybase to develop and market tools and application examples on the RS/6000 platform. This partnership tackles both problems in an attempt to convince customers that their initial investment will be worthwhile for the long haul.

Looking ahead

Overall, the quickest and easiest route to profitability in the defense-conversion race may be for businesses to emulate the coalition/alliance-based model already up and running in Silicon Valley. This business model may prove to be a blueprint for economic recovery elsewhere, particularly in regions already equipped with a high-tech industry base, such as the Route 128 belt in Massachusetts.

By teaming with related (or interrelated) industries, companies can exploit the strengths and resources of competitors to mutual advantage. This industrial commensalism allows companies to concentrate on manufacturing and selling the best products and services available in the marketplace.

Most important for the economy, though, is the innovation that results from collaboration. New technologies and products evolve and spur new markets, which increases profits. New products and technologies also demand a larger and better skilled workforce. Consortia help form networks and manufacturing/technology alliances, which involve corporate executives, scientific researchers, and factory workers alike. Obviously, demands for across-the-board employment fuel more than just the local economy.

Fostering an entrepreneurial spirit via a loosely aligned network of autonomous companies is a blueprint for future economic success. It speeds technology sharing via enhanced communication. And it helps innovation thrive. The foundation of the 21st-century "Information Age" may prove that a free flow of proprietary information doesn't hinder profitability but rather works to ensure it. EDN

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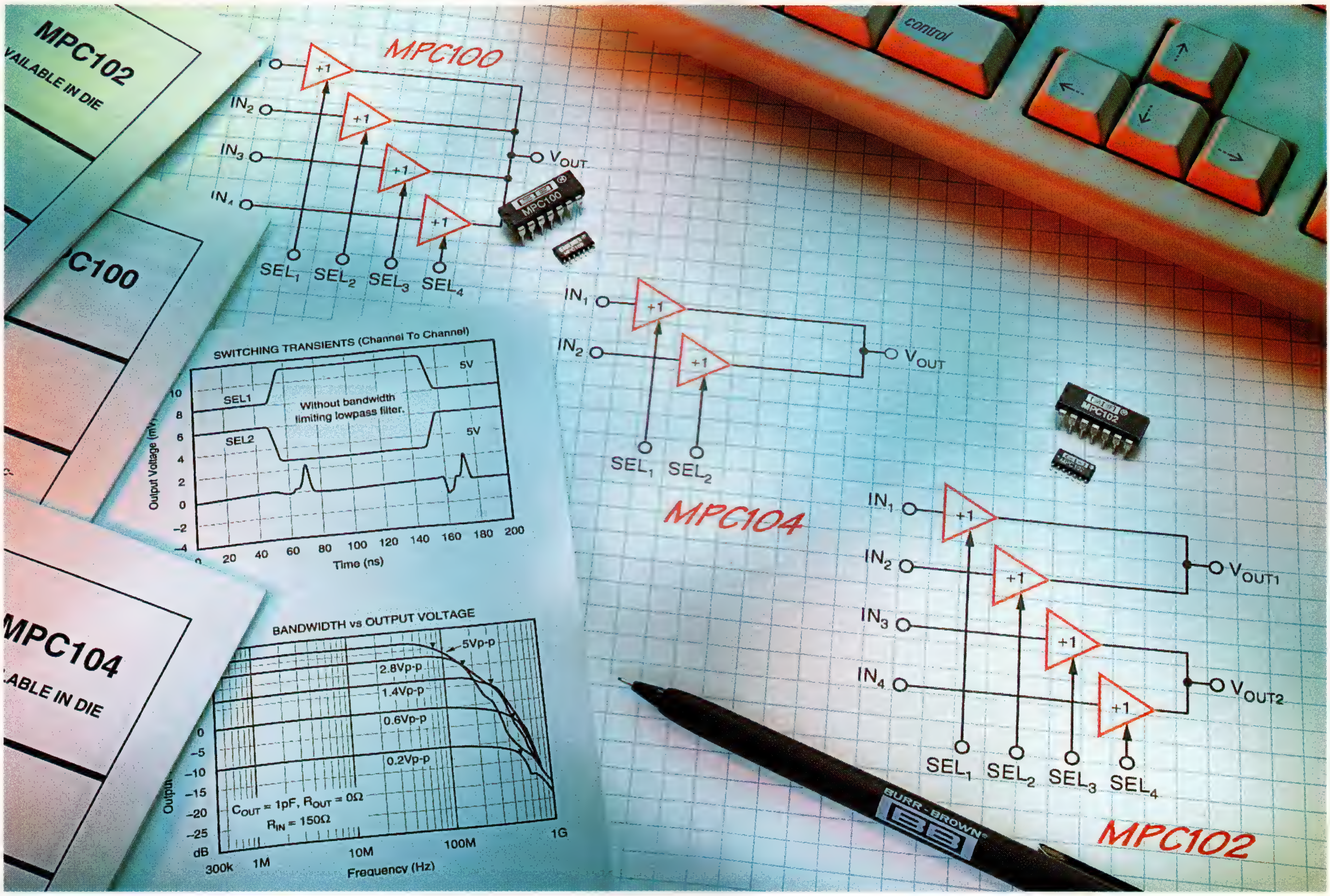

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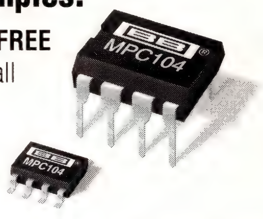

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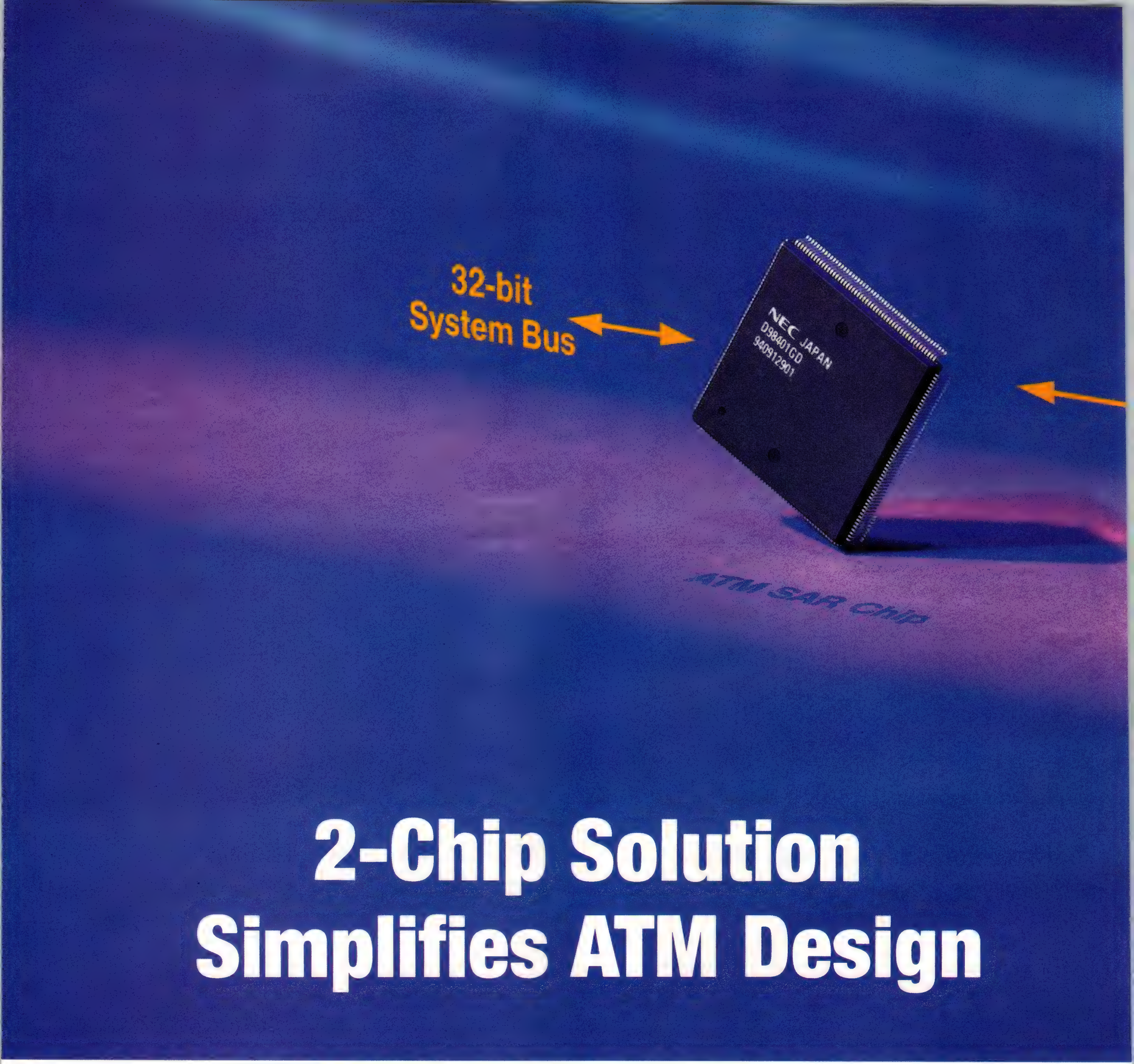

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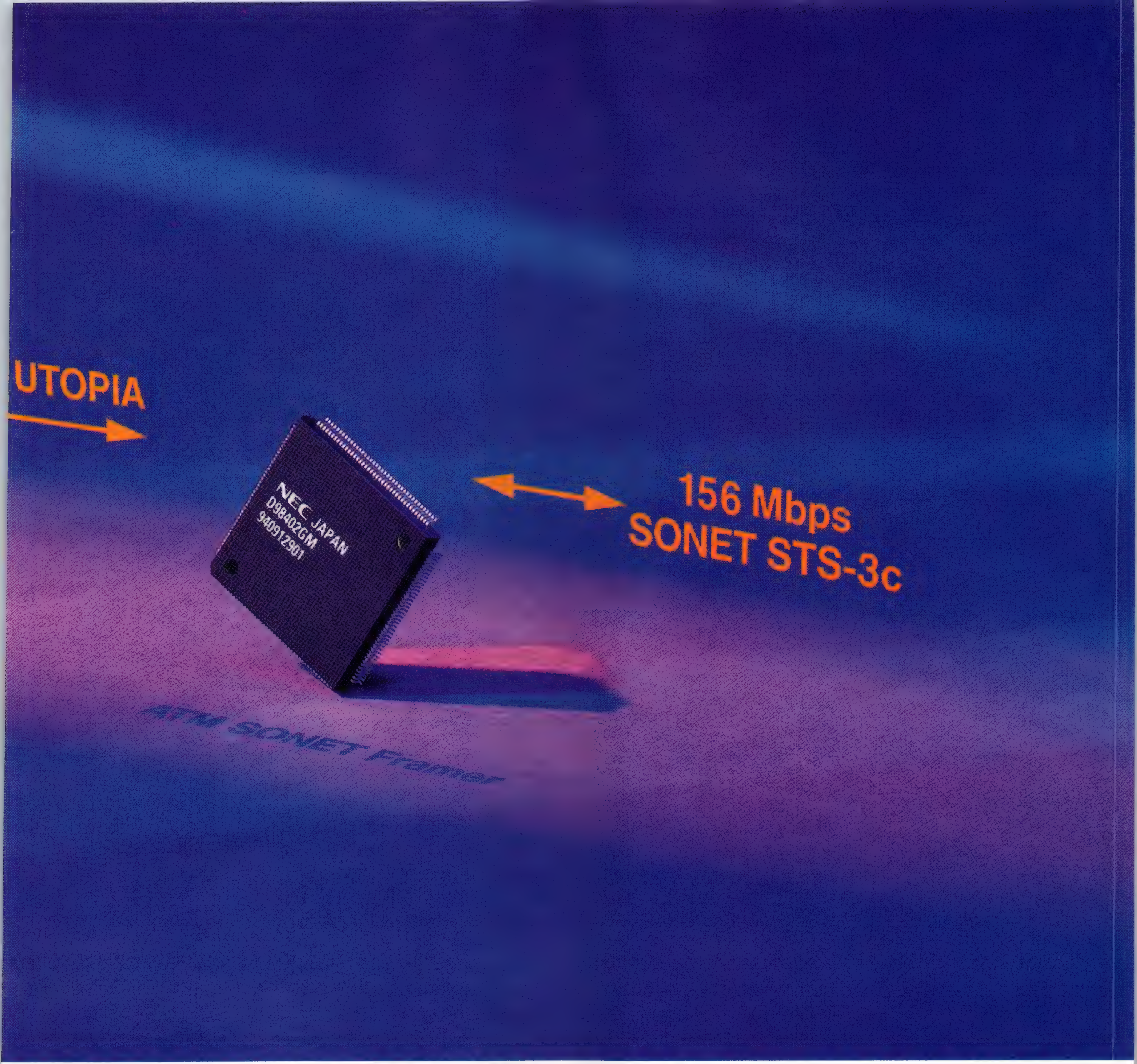

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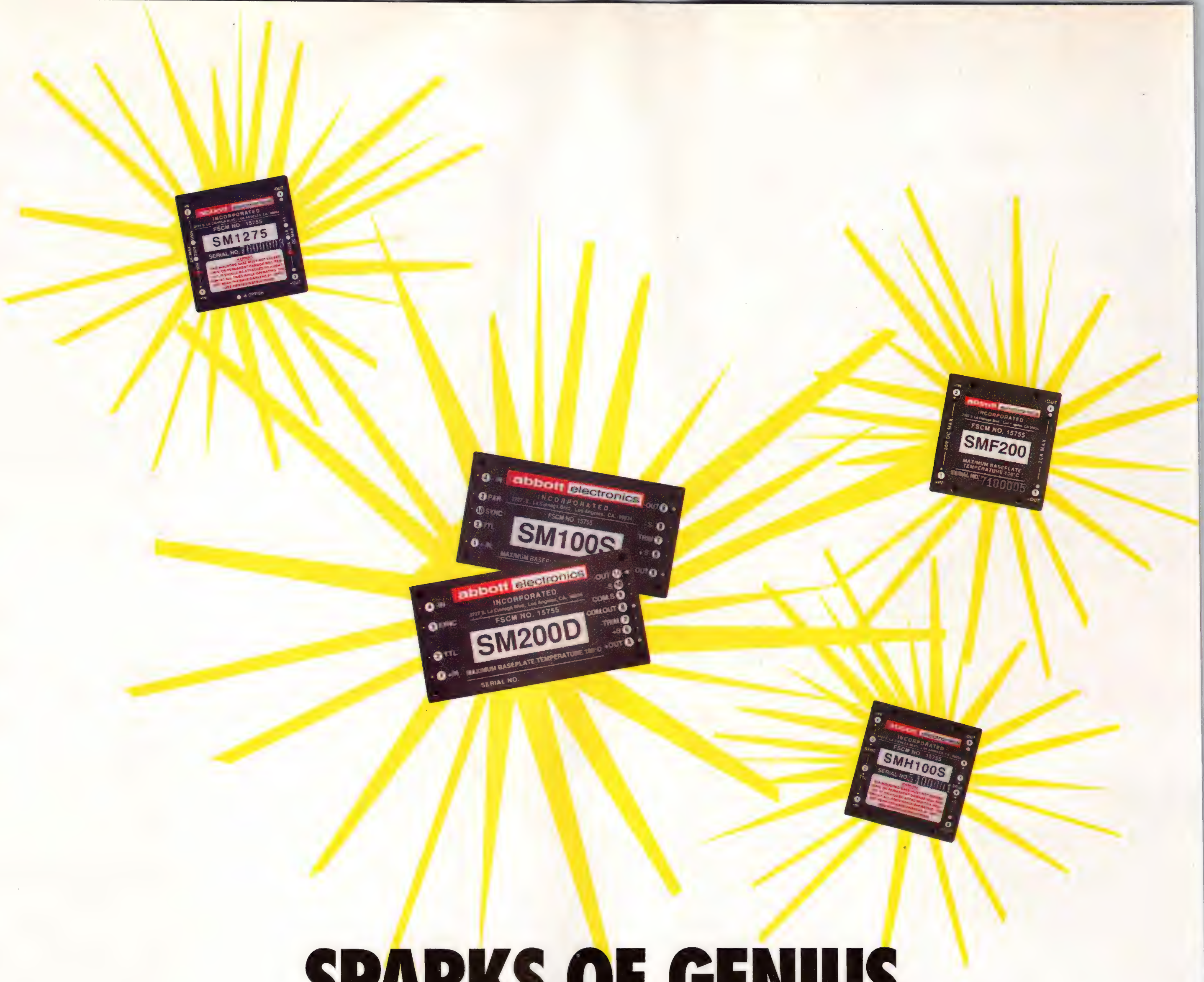

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ESL's new-venture process offers defense companies a commercial future

RICHARD A QUINNELL, TECHNICAL EDITOR

When the Berlin Wall came down in October 1989, the world sighed its relief from the combat-ready tension that history calls the "Cold War." US companies that depended on Department of Defense procurement contracts for their livelihood, however, felt relief mingled with a new concern. How would they survive with demand for the tools of defense on the decline? ESL Inc, a TRW company, came up with an answer.

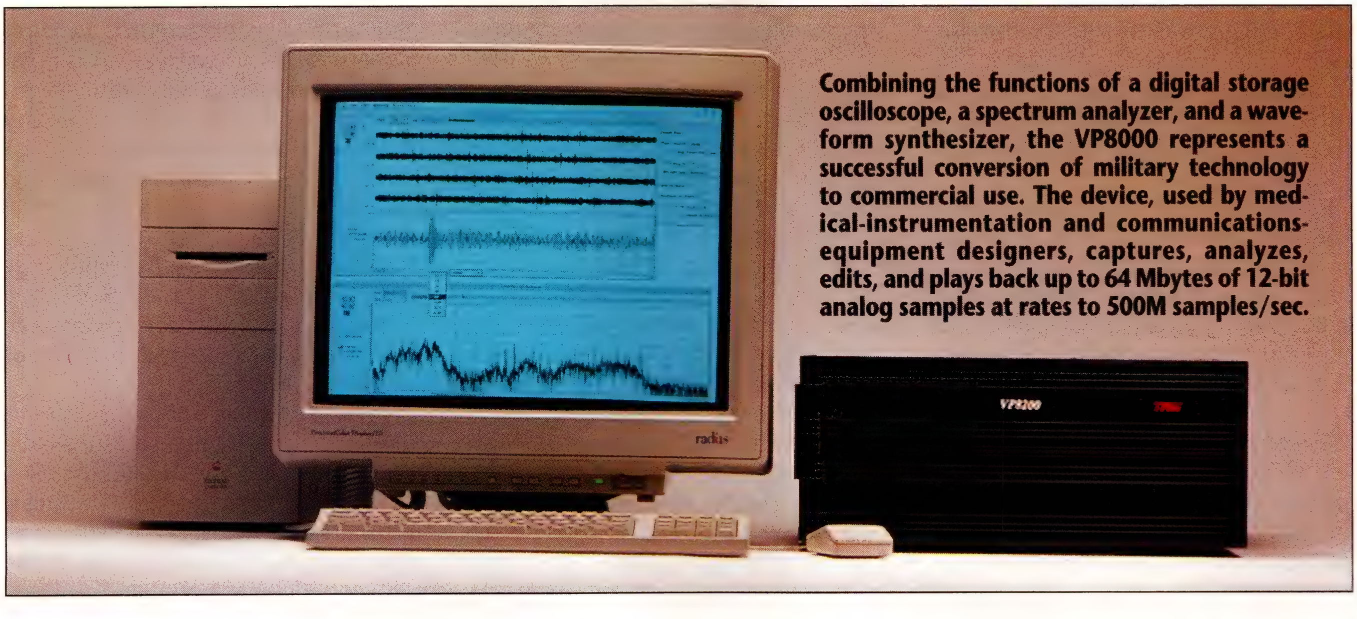
ESL's post-Cold War economic survival was not a pressing question when Arthur L Money became company president in January 1990. The company was financially healthy and still had plenty of defense work to keep it going. But the question was a haunting one, invoking the specter of slow financial starvation as ESL's customers inevitably reduced their defense spending.

To dispel that specter, Money envisioned his company as still healthy and viable in 2020, augmenting defense revenue with a new line of commercial businesses. Focusing on this 2020 vision, Money and ESL developed a system for generating businesses within ESL—businesses that would convert the company's defense expertise into civilian products.

The Cold War's end brought defense-budget reductions. So defense contractor ESL Inc found a way to pursue civilian opportunities.

ESL's movement into commercial ventures began in 1992 with an attitude adjustment. The company started sending its employees to lectures by futurists and management gurus. The idea: to stimulate thinking outside the typical defense-industry paradigm. More than 120 of ESL's employees attended those lectures during the year.

Next, the company grouped people into idea factories. Their task was to brainstorm ideas for markets and products toward which ESL could turn its talents. Jeffry W Phillips, managing direc-



Combining the functions of a digital storage oscilloscope, a spectrum analyzer, and a waveform synthesizer, the VP8000 represents a successful conversion of military technology to commercial use. The device, used by medical-instrumentation and communications-equipment designers, captures, analyzes, edits, and plays back up to 64 Mbytes of 12-bit analog samples at rates to 500M samples/sec.

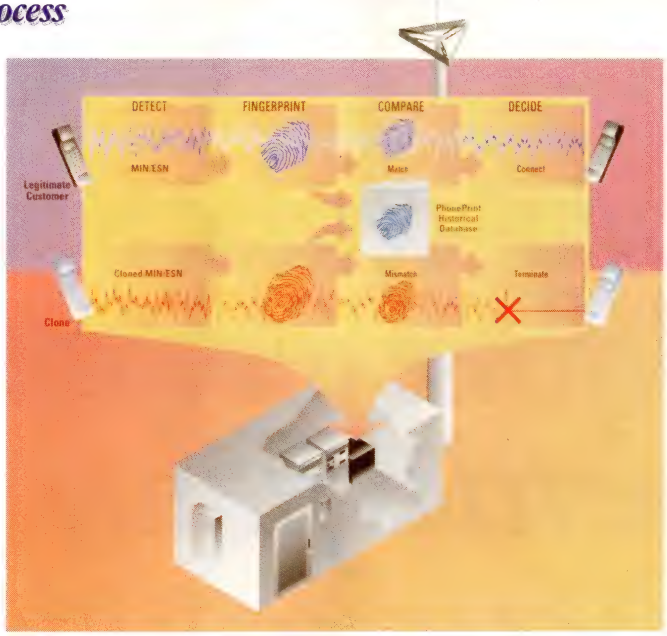
tor of TRW Wireless Communications (one of the first spin-offs from the new-venture system), recalls that the idea factories took a while to catch on. Once they did, however, they *really* caught on. "People came in with all sorts of ideas," Phillips remembers, "and some of them were off the wall. But some of them were pretty good."

By the year's end, the company had given serious consideration to 18 of those ideas, and six became the nuclei for new businesses. In addition, the company developed a formal system for evaluating new-venture ideas (see **box**, "Hatching a new venture") and staffed a new-venture incubator facility for helping employees refine and strengthen their initial concepts. Further, it set a firm goal: 25% of the company's revenue must come from nondefense business by 2000.

Establishing its new-venture process was not an easy task at ESL. One of the first problems the company had to overcome was its narrow defense-oriented mindset, which focused on technology because the customer's needs were already well defined. "In a defense company, you have a tendency to think internally," says ESL's New Ventures Director Catherine A Kitcho. "It's very tempting to live inside your own intellectual world." To broaden its horizons to encompass the commercial world, the company had to shift its thinking away from technology. "What we found works," says Kitcho, "is to get people to think of market needs first, rather than starting with the technology and trying to fit it in."

Recognizing its need to acquire market savvy, ESL hired business consultants and marketing experts. It also found its people lacked basic business skills. Highly technical people needed to learn the fundamentals of marketing, finance, and business operations. So ESL retrained its staff.

Once the employees began generating new-venture ideas they wanted to pursue, the company ran into another problem: conflict of priorities. Project managers were sometimes resistant to new-venture proposals. The venture might be a good idea, but the managers didn't want their projects to lose key personnel to the venture. "This is where support and commitment at the top make a difference," says Kitcho. And, at the beginning, some conflicts did go all the way to the top for resolution. Now, Kitcho notes, managers understand the new ventures' importance to the company and work out compromises.



Turning its military reconnaissance skills to civilian use, ESL developed the PhonePrint System. The system determines an electronic fingerprint for cellular phones, allowing identification of fraudulent calls.

Corporate management alone can't resolve some of the problems ESL still faces. One of the most critical is the US government's procurement process. That process requires the vendor to obtain and fully document three bids on all parts and subcontract services in building a product for sale to the government. The result is a tremendous purchasing overhead that is inconsistent with the needs of a commercial venture. Government requirements on accounting procedures, security, and intellectual-property rights are also at odds with commercial practice. ESL and other defense companies are lobbying Congress to amend those requirements. In the meantime, they find themselves needing to duplicate departments such as purchasing and accounting to operate a commercial venture.

Along with problems, however, come answers, and ESL has learned valuable lessons along the path to defense conversion. Based on those lessons, ESL has a variety of suggestions for any defense company seeking to expand into commercial businesses. One of the first suggestions is to start while the company is still financially healthy. As Kitcho notes, "It's difficult to invest in new ideas while the company is downsizing."

Another suggestion is to be certain that the expansion effort has the full support and commitment of top management. Further, management needs to communicate that commitment. Otherwise, current projects can suppress the development of new ideas and products by hoarding personnel and resources, and the company's future gets sacrificed to satisfy current needs.

To recognize where new opportunities lie, companies need to identify their core areas of expertise. That identification includes examining the company's overall knowledge and skill base, not just the technologies it has developed. In ESL's case, that identification revealed expertise in digital signal acquisition and analysis as well as the handling and interpretation of large databases.

Along with recognizing core skills, companies need to identify where holes in their skill set lie. In ESL's case, those holes included a lack of marketing skills and ignorance of commercial business practices. Once they find the holes, companies need to hire the best available talent to fill them.

ESL also suggests avoiding head-on competition with commercial companies when cost is a major customer concern. Defense companies typically don't have the necessary experience in high-volume, low-cost manufacturing. Instead of head-on competition, ESL recommends that defense companies identify opportunities where their core capabilities give them a competitive advantage, allowing them to provide customers with products they need but can't obtain elsewhere.

For example, ESL's core expertise in signal acquisition and handling large databases, derived by developing electronic-reconnaissance and tactical-information systems, enabled it to create several such products. One is the VP8000 wideband signal-and-test system, developed to meet the needs of communications-equipment and medical-instrumentation developers who want to capture and synthesize wideband signals for testing their designs.

The VP8000 combines a 500M-sample/sec data-acquisition and signal-generation system with signal analysis and database-management software running on a host computer (Unix-based or Macintosh Quadra). That combination allows the VP8000 to act as a digital storage oscilloscope, a real-time spectrum analyzer, or a waveform synthesizer, all under software control. The unit holds 64 Mbytes of 8- or 12-bit sample data for analysis and display or for waveform synthesis. The host system holds additional data.

Designed for both defense and civilian use, the VP8000 employs a modular architecture to allow users a variety of configuration and cost options. The options include interface cards for general-purpose analog and digital signal acquisition and generation that are suitable for direct connection to CDMA/TDMA communications networks. The price ranges from $50,000 to $90,000.

Another application of ESL's core expertise led to the PhonePrint network-access controller, developed to help control cellular telephone fraud. Fraud occurs because cellular telephones broadcast an identity code to the network to get a dial tone. Telephone pirates capture those codes off the air from legitimate calls, then program clone phones to use the stolen identity codes. The legitimate user winds up getting the bill.

The PhonePrint system uses high-speed RF-signal capture and analysis to create an electronic signature for each

HATCHING A NEW VENTURE

To find profitable civilian outlets for its skills and capabilities, defense-contractor ESL Inc developed a process for evaluating and nurturing new-venture ideas. The process includes periodic evaluation by a director-level review board and nurturing of promising ideas in a new-venture incubator. The incubator is both a place and a staff to help idea proponents refine venture proposals and validate their market potential.

The process has proven successful at ESL and has inspired other defense companies to follow suit. An industry group dedicated to helping its members survive defense budget cuts, the Silicon Valley Defense/Space Consortium, has recommended the ESL process as a model for its own members' conversion efforts. **Fig A** shows the overall flow of the ESL new-venture incubation process.

The process begins with an idea, which anyone at the company is free to propose. Along with an idea, however, the proponent must provide a list of potential customers and initial answers to other questions that explore the idea's fit with the company. As with other entrepreneurs, the work to develop the idea comes out of the proponent's personal initiative. The incubator's resources are available, however, to help the proponent prepare the idea for review.

The review board meets every week to examine new-venture proposals. They ask six critical questions:

1. What is the idea's fit with the company's core competencies and strategic goals?

2. What is the market for the product or service; that is, how large is the market, who are the customers, and what is their motivation to buy?

3. How does the product price compare with its cost to create, its value to the customer, and competitive products?

4. What is the product's production cost, and what margins will the product generate?

5. What investment, in personnel and finances, is needed to bring the product to market?

6. What is the venture's five-year forecast for finances and return on investment?

If it approves the proposal, the board authorizes funding for the proponent to validate Question 2's answer: the proposed market. Working with the new-venture incubator's team, the proponent can now spend company time refining the venture proposal—but only some company time. These in-house entrepreneurs still need to make a personal investment. "They are working more than 40 hours a week," notes Catherine A Kitcho, director of ESL's new-ventures program, "but compared to creating their own start-up, the risks are a lot lower."

The market-validation phase takes about a month. If the proponent demonstrates to the review board that there is a sizable and valid market for the proposed product, the board funds a venture team to create a business plan. At this point, the project begins to more closely resemble a start-up company. The venture team must prepare the same type of business plan that venture capitalists in Silicon Valley demand before providing funding. The team may even build a demonstration system or perform proof-of-concept experiments.

Finally, the venture team presents its plan and market analysis to the review board and the company president. Acting as its own source of venture capital, the company approves the proposal and begins funding for a venture launch. The venture team begins acquiring personnel, supplies, and facilities. A new business unit of TRW/ESL has hatched and is ready to grow.

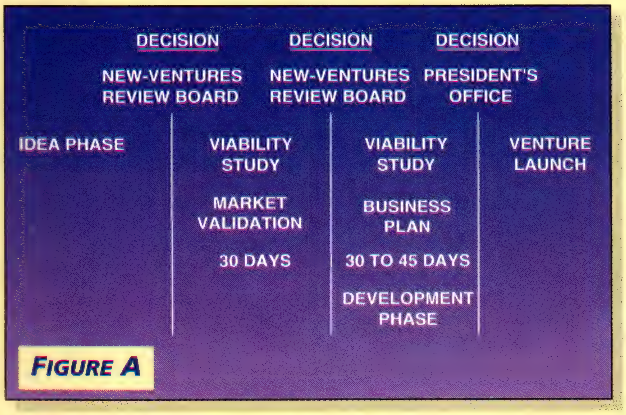
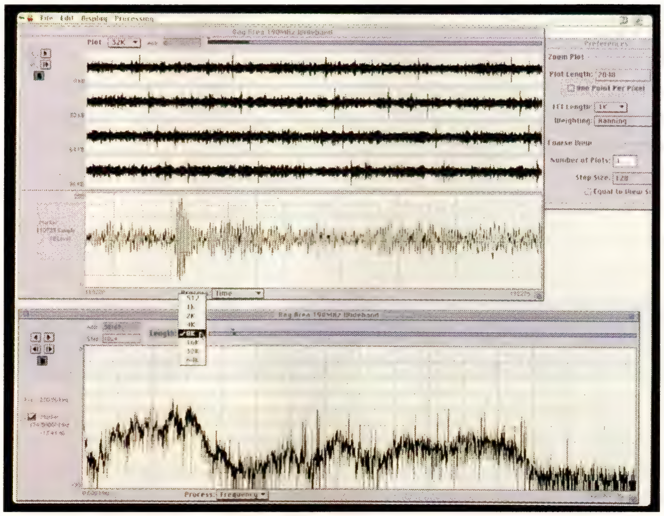


FIGURE A

Beginning with an idea and ending with a new business, ESL's new-venture process both nurtures and scrutinizes in-house proposals. The company provides an idea incubator to help engineers with product ideas obtain needed marketing savvy.

cellular telephone attempting to access the network. Because each legal cellular telephone uses a unique identity code, the code and the phone's electronic signature correlate. The system maintains a database of identity codes and the corresponding signatures. By comparing an incoming call's signature with one on file for the identity code the call used, the system determines if the call is legitimate or fraudulent.

When PhonePrint discovers a signature that doesn't match its file, it signals the telephone system to deny that caller access to the network. The process takes the PhonePrint system less time than the telephone system needs to establish a channel for the incoming call. Legitimate callers, therefore, gain access to the cellular network without additional delay. The fraudulent caller never gets a dial tone.



ESL's expertise in handling large databases resulted in a unique data-browsing capability for the VP8000 wideband signal-and-test system. The unit simultaneously displays its 64-Mbyte sample memory, a magnified sample subset, and spectral analysis of that subset. Users can roam through sample memory at random without waiting for data transfers from the host workstation.

Both the VP8000 and PhonePrint illustrate use of ESL's core capabilities, derived from military experience and applied to civilian problems. Neither are old military products looking for a new home. It is that focus on applying capabilities, not reapplying product technology, that ESL believes will keep defense-conversion efforts successful.

According to Phillips, partnering is a key aspect of finding opportunities to apply a company's core expertise. Partnering allows a major customer to help refine a product proposal. "You need to link up with partners that have domain expertise," he says. That expertise provides the defense company with invaluable insight into the problems facing the customer's industry and helps ensure design of a viable product.

Finally, ESL recommends that defense companies start small with new commercial ventures and build them up as revenues increase. Starting small keeps initial expenses down and promotes among venture team members an entrepreneurial spirit and a tight-budget mindset. Most of ESL's new ventures, notes Kitcho, began with fewer than 20 people. The idea, adds Phillips, is to treat the new venture as a start-up company, not just another project within a large corporation. The start-up mimicry at ESL includes equipment and furnishings. "Even the building selection was made to mimic a start-up environment," jokes Phillips, gesturing at the cramped quarters and Spartan furnishings of ESL's new TRW Wireless Communications venture.

Following its own recommendations, ESL has come a long way toward realizing Money's vision of 2020. The company's nondefense businesses are generating income, promising to be 10% of the company's annual revenue this year. Meanwhile, the company's new-venture incubator continues to hatch business plans that should help the company attain its 25% nondefense revenue goal well before the target of 2000. ESL's new-venture incubation is its answer to the question of post-Cold War survival. EDN

Technical Editor Richard A Quinnell can be reached at (408) 685-8028, fax (408) 685-8028.*

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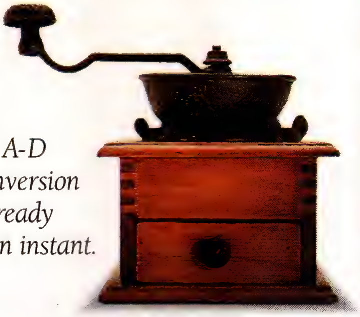

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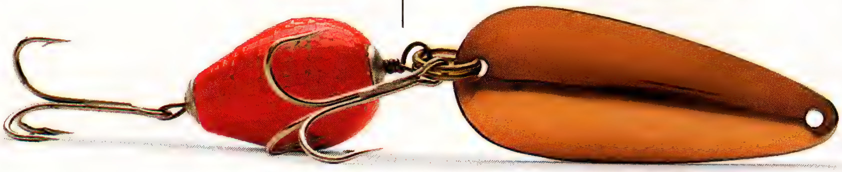

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CIRCLE NO. 86

RAYTHEON PUTS MILITARY SAVVY TO CIVILIAN USE

Following World War II, Raytheon harnessed the power of military radar to invent microwave cooking. Today, the company is finding new opportunities to diversify defense technology into commercial markets.

FRANCES T GRANVILLE, SENIOR ASSOCIATE EDITOR

The Iridium satellite-based personal-communications system will employ Raytheon's GaAs monolithic microwave ICs.

AS DEFENSE SPENDING CONTINUES TO SHRINK, Raytheon Co, among other large defense contractors, is scrambling to expand its defense technology into the commercial market. The Clinton administration calls this effort "defense reinvestment," but it also goes by the names "conversion," "diversification," and "dual use."

No matter which buzzword you choose, though, the administration hopes that the reinvestment effort will provide a major boost to the US economy. Toward that end, in 1991 the government initiated the Technology Reinvestment Project (TRP), a $575-million federal-grant program under the Advanced Research Projects Agency. The TRP, which provides as much as 50% of the funding for selected defense-conversion programs, recently chose

RAYTHEON STRATEGY

Raytheon's Electromagnetic Systems Division for a defense-conversion grant to develop commercial uses for military telecommunications technology.

As leader of the $18.4-million project, Raytheon (Lexington, MA) will oversee the development of four broadband digital telecommunications prototypes during the next two years. According to the company, the technology will provide 10 times the performance of current commercial communications equipment. Its potential applications include computer networks, high-definition TV, and aircraft avionics.

In addition to the grant, Raytheon has many other irons in the reinvestment fire; areas of diversification include satellite communications, air- and vessel-traffic control, air safety, automated vessel alert, personal rapid transit (PRT), infrared (IR) imaging, telemedicine, automated highway systems, and high-speed rail systems.

Last month, the company won a $1-billion contract with Brazil to build the Amazon surveillance system (SIVAM) in the Amazon rain forest. Brazil will use the system, which will draw heavily on the company's military telecommunications and satellite technology, to monitor drug and mineral smuggling, protect tribes, reduce deforestation and decimation of wildlife, and improve communications in remote areas.

In another project, Raytheon has exploited its military expertise to become a major participant in Iridium Inc's satellite-based personal-communications-system project (see **box**, "Communicating by satellite"). In the

COMMUNICATING BY SATELLITE

PART OF RAYTHEON'S DEFENSE-REINVESTMENT STRATEGY is its role in Iridium Inc's satellite-based personal-communications network, called Iridium. The network calls for a satellite-launch schedule to begin in 1997, with commercial service beginning in 1998. As a major subcontractor, Raytheon is part of Iridium Inc, a recently formed corporation comprising 13 international investors, including US participants Lockheed, Motorola, and Sprint.

Raytheon will develop the main mission antennae for the satellites, and Motorola will develop and produce the satellites at its Satellite Communications Division (Chandler, AZ). Motorola holds a 27.25 share of Iridium. Among the other participants in the project are contractors for launching the satellites. The project's multiple launchers include McDonnell Douglas Delta 2 rockets, each carrying five satellites; Khrunichev Enterprise Proton rockets, each carrying seven satellites; and China Great Wall Industry Corp Long Mach IIc rockets, each carrying two satellites.

According to Iridium Inc spokesman John Windolph, the name "Iridium" comes from the periodic table of the elements. Because the project originally called for 77 satellites, it was called Iridium, after the 77th element on the table. However, Raytheon's improvement of the antennae's signal power effected a reduction in the number of satellites to 66. (The 66th element on the table is Dysprosium, hardly an alluring name, especially from a marketing standpoint, Windolph says.)

Bob François, program manager for the Iridium main-mission antenna in Raytheon's Wayland, MA, facility, says that Raytheon effected a tenfold increase in signal strength by reducing to three the number of planar phased-array antennae from the original prototype's seven and by making the antennae substantially larger—each measuring about 34×74 in. Resembling a honeycomb, a phased-array antenna contains hundreds to thousands of independently radiating elements. The antennae steer the satellite's beam by controlling the phase at each radiating element.

Another signal-enhancing technique was to increase the antennae's gain, or focusing power, thus increasing the power density on the ground. Raytheon increased the number of spot beams, or cells, per satellite footprint—the flashlight-beam-like circle that is focused onto the ground. The satellites now incorporate 16 spot beams per antenna for a total of 48 spot beams per satellite footprint—up from the original prototype's 37. The company also improved the system's link margin—the theoretical minimum bit-error-rate requirement—from 9 dB in the original version to 16 dB (vs the 3 dB standard in other communications systems). All these improvements yielded a higher signal quality that allows users of the system to access it under trees, inside automobiles, and inside and behind buildings.

The Iridium network will comprise a "constellation" of 66 1500-lb satellites—each incorporating 2000 of Raytheon's monolithic microwave ICs—in low Earth orbit, about 420 nautical miles above the Earth. Compared with geostationary communication satellites 22,300 nautical miles above the Earth, the low orbit of the satellites will allow the satellites to project more tightly focused beams onto the ground, ensuring strong signals and high-quality communications.

The low orbit will also minimize echo and allow for a small-enough antenna on the subscriber unit for users to carry the device in their pockets. The satellites will operate on six orbital planes, with 11 operational satellites and one on-orbit spare per plane.

Iridium will permit any type of telephone transmission—voice, data, fax, or paging—to reach its destination anywhere on Earth at any time. The subscribers units transmit voice at 4.8 kbps and data at 2400 baud through digital facilities to communicate with any other telephone in the world. The telephones feature QPSK modulation with frequency-division/time-division multiple access.

Unlike conventional telecommunications networks, the system will track a telephone handset's location, providing global transmissions even if the subscriber's location is unknown. Once a user activates an Iridium telephone, the nearest satellite automatically determines account validity and the user's location. The subscriber selects either cellular or satellite transmission alternatives, depending on compatibility and system availability. If a cellular system is not available, the dual-mode telephone communicates directly with a satellite overhead and transfers the call from satellite to satellite through the network first extensive commercial application of a space-based phased array, Raytheon will provide the main mission antennae of the satellite.

Although conversion is not always easy—and, in some cases, may even fail—the Iridium project makes good use of the company's established experience as a defense contractor, according to Bob François, program manager for the Iridium main mission antenna in Wayland, MA. "In this case," says François, "conversion was relatively straightforward because we had all the technical expertise in place, and we had one customer," unlike in commercial ventures when companies typically have to seek multiple customers.

But there were challenges in the Iridium project. "With the government, you do business under a set of rules not always the most cost-effective. With Iridium, we had to be cost-effective," states François. "You don't want to throw the baby out with the bath water, though," he cautions. Thanks to its extensive experience in careful parts selection and screening to meet military requirements, Raytheon was able to meet the high-quality requirements of space hardware. Most commercial hardware does not require such high standards, François says. After all, anything you launch into space—or into battle—should be top-quality. Another reason for careful parts selection and screening is the tremendous investment Iridium represents.

Two other aspects made conversion easy. First, the phased-array antenna for Iridium is the same type of antenna Raytheon employs in its PAVE PAWS radar that watches for submarine-launched ballistic missiles. Second, the antennae will employ Raytheon's

to its destination—either another Iridium telephone or an Iridium ground station.

Gateways interconnect the satellite network with land-based fixed or wireless communications. Gateways interface with public switched telephone networks and with the Iridium constellation. The communications links are L-Band for Iridium telephone communication and Ka-Band for intersatellite links, gateways, and feeder-link connections.

Applications for Iridium include providing workers the ability to stay in contact with offices continents away, service for developing nations without telecommunications infrastructures, communications for rescue and supply efforts during natural disasters, and personal use. Demand for these services is on the rise, according to a June 1993 report by the US International Trade Commission. The report predicts that the worldwide market for personal communications will account for annual revenues of up to $60 billion by 2000. The commission also forecasts that the number of subscribers will reach 150 million.

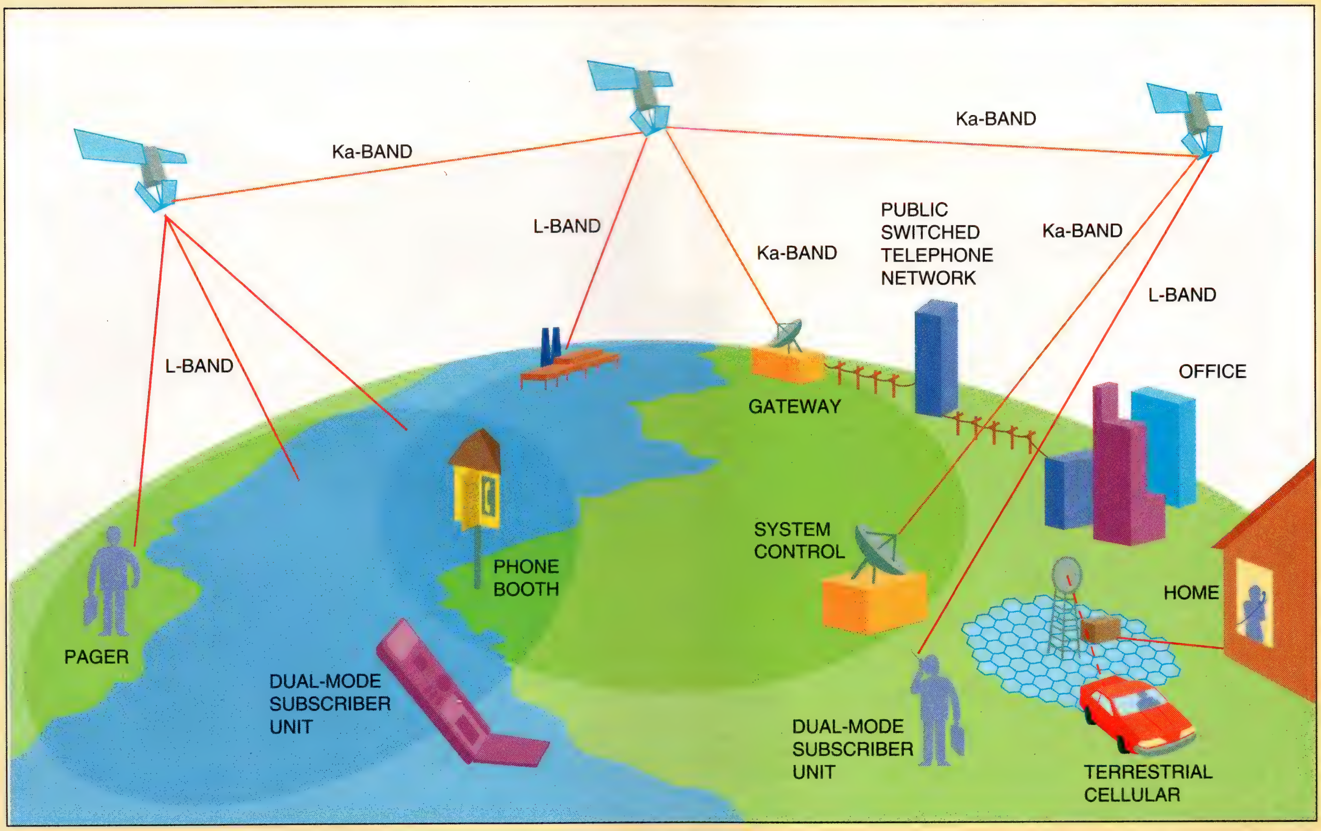


ILLUSTRATION / E. ROBBINS

Using satellites, communications links, and gateways, Iridium will allow voice, data, fax, and paging transmission to hand-held handsets.

monolithic microwave ICs (MMICs), which the company produces at its Advance Device Center (Andover, MA), to generate and receive microwave signals. These MMICs are the same type of chip Raytheon uses in its Patriot missile system and its ground-based radar for defense against tactical ballistic missiles.

In addition to the Iridium project, Raytheon has shipped approximately 125,000 commercial MMIC down-converters for TV satellite receivers and has contracts to develop the chips for wireless LANs.

Defense radar controls air traffic

Air- and vessel-traffic control are other areas in which Raytheon has made significant use of conversion. As developer of the magnetron—the heart of radar—the company is diversifying its defense-related radar technology for use in air-traffic control and air safety. Last year, the company received two contracts from the National Airports Authority of India and two from the civil aviation authority of Oman. The Indian projects include radar, navigational aids, displays, and air-traffic control. The Omani contracts are for automation equipment, displays, and primary and secondary radar systems.

In the United States, the company is part of the Federal Aviation Administration's (FAA's) Advanced Automation Systems project. As such, it will provide as many as 7500 color air-traffic-control consoles and as many as 2300 displays for airport-control towers. The company also has completed the preliminary design of a Category II/III Microwave Landing System for the FAA.

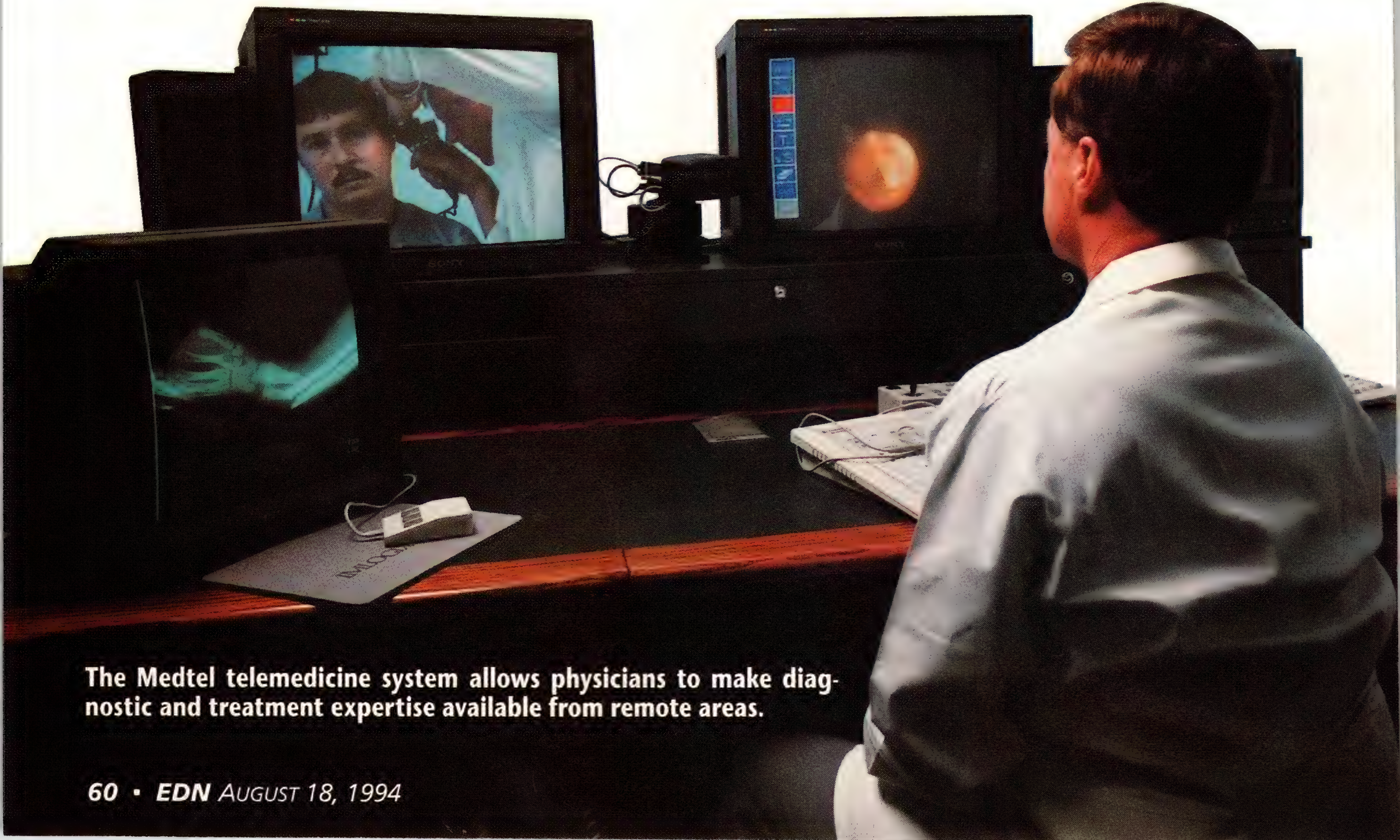
In air safety, the company is applying its terminal Doppler weather radars (TDWRs) in airports nationwide. The TDWRs will warn air controllers of sudden wind shifts, such as microbursts, which analysts blame for air accidents, especially during takeoffs and landings.

Using the same military radar, the company has contracted with the US Coast Guard's vessel-traffic services (VTS). Under terms of the contract, VTS will use Raytheon's automated dependent surveillance system in Prince William Sound, AK. The system uses global-positioning-system satellites and marine radars to provide information on marine traffic within the 4000-sq-mile sound.

In addition to radar, Raytheon is employing its military sonars in commercial products. For example, in cooperation with Coastal Corp, Houston, Raytheon has built the first production prototype of the Avert automated vessel-alert system. The system will prevent tankers and other commercial ships from hitting rocks and reefs.

IR imaging is another area in which Raytheon is parlaying its expertise in defense into commercial use. IR imaging uses differences in heat to "see" objects, a key ability of advanced defense systems. The company has developed the Radiance 1 IR camera for commercial applications, such as night surveillance, nondestructive testing, and medical imaging. The camera looks like and weighs about the same as a video camera. Because Radiance 1 can detect differences in temperature as small as 0.045°F, the National Aeronautics and Space Administration (NASA) employed the device to track the Space Shuttle Endeavor when the shuttle was more than 200 miles away and during a night landing.

NASA also employed Raytheon's IR technology in 1994 on the spacecraft Clementine. The Raytheon IR imaging equipment gathered data about the moon and a new asteroid. In addition, Raytheon has developed and fabricated an IR focal-plane array that mimics the



The Medtel telemedicine system allows physicians to make diagnostic and treatment expertise available from remote areas.

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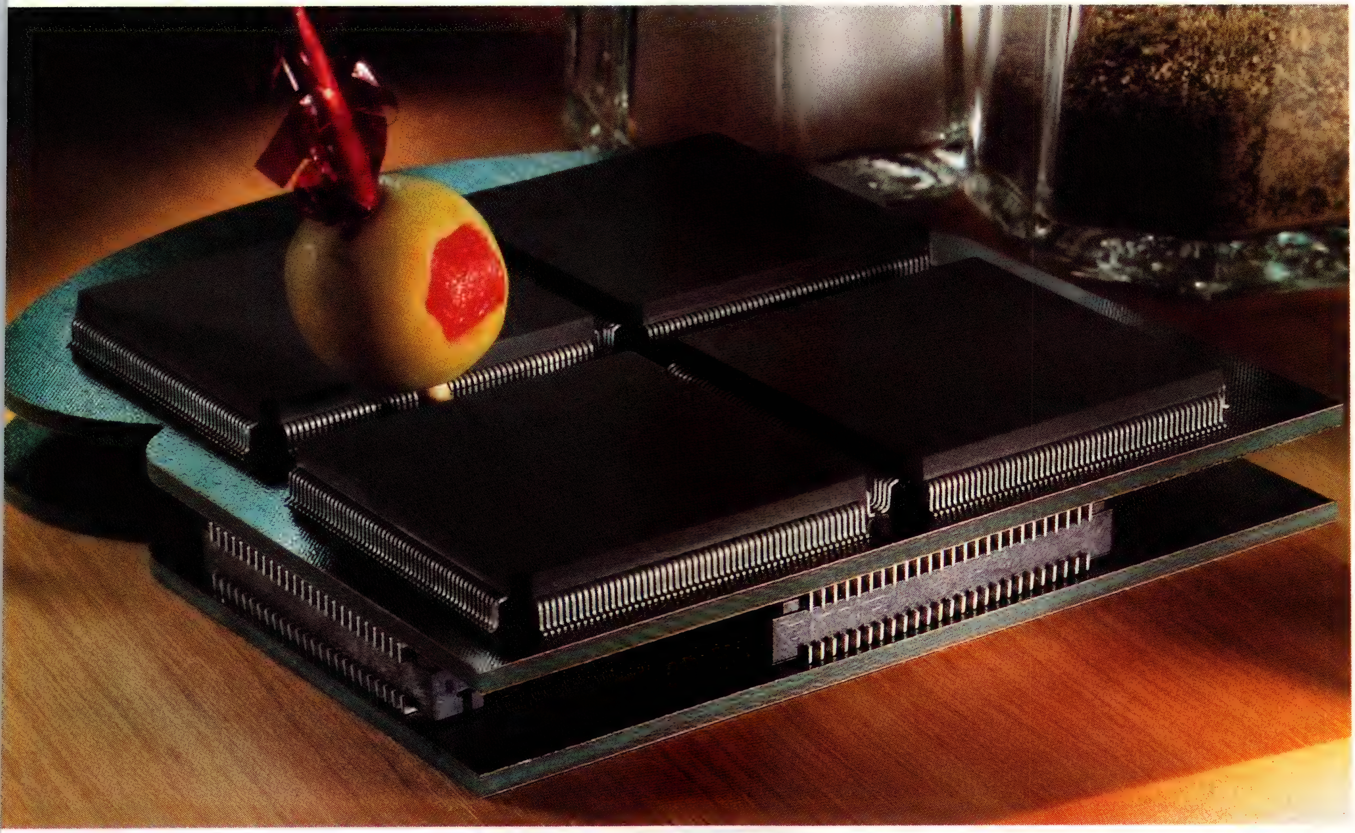

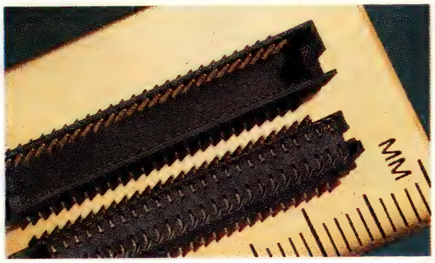

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AMP

CIRCLE NO. 9

function of the human eye. This "neuromorphic" device has potential applications in motion detection.

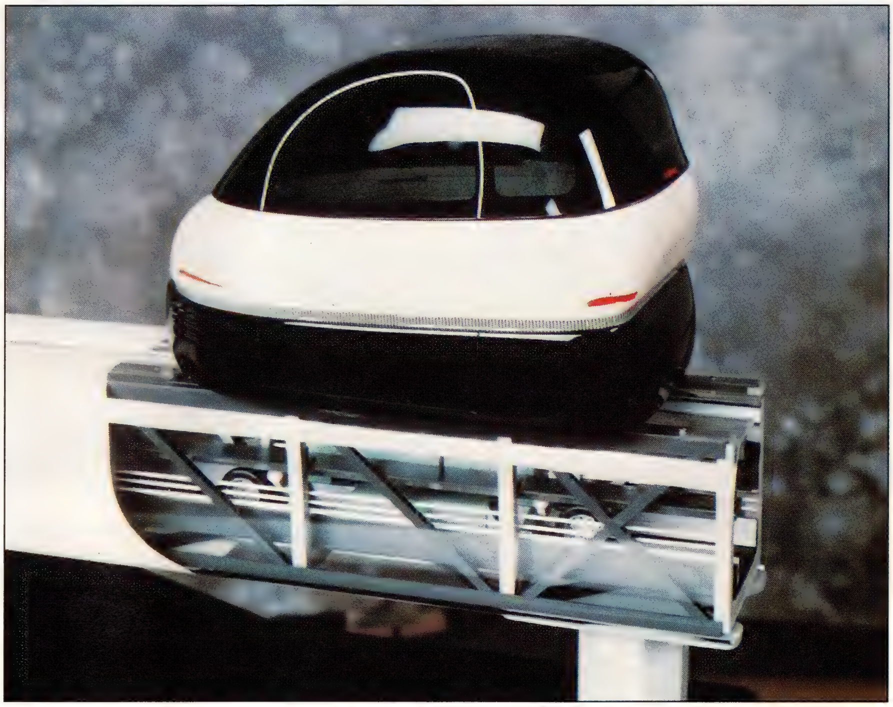
In another area of conversion, telemedicine, Raytheon is exploiting its expertise in developing telecommunications networks for the military. The company has entered a joint venture with renowned heart surgeon Dr Michael E DeBakey and Interactive Telemedical Systems. The group has introduced the Medtel system, which allows medical specialists to examine and diagnose patients anywhere in the world. The system will have access to the Texas Medical Center, which encompasses five universities and 14 major hospitals treating 3.6 million patients.

Medtel will seem like a virtual-reality environment, allowing doctors to use electronic stethoscopes, to examine patients' eyes and ears, and to analyze X-rays and pathology smears as if the patient were physically present. Raytheon's contribution will include information-processing technology, telecommunications systems, project management, and infrastructure development. The company will also provide training and maintenance services for the Medtel network and client organizations. Potential applications include prenatal sounding, newborn examinations, and preventive checkups for the elderly in remote rural locations; emergency trauma diagnosis and treatment advice in accidents and natural disasters; screening of candidates from developing areas for costly travel to distant medical centers for treatment; and responding to possible medical emergencies aboard space stations.

Planes, trains, and automobiles

In an effort to diversify into the commercial transportation business, Raytheon is addressing three areas: PRT, automated highways, and high-speed rail. The company recently won a contract with the Northeastern Illinois Regional Transportation Authority to develop and demonstrate a PRT system. The authority plans to install the system in Rosemont, IL, to alleviate automobile traffic. The system will include 45 vehicles on 3 miles of dedicated steel "guideways" elevated on slender pylons. The PRT system will connect hotels, office buildings, the O'Hare Expo Center, and the River Road Transit System via small vehicles seating one to four people. The vehicles will depart on demand and each will carry its own switching system, eliminating the need for conventional and potentially hazardous in-track switches.

Before developing the Rosemont system, Raytheon will demonstrate a three-vehicle model of the system at the company's Marlborough, MA, facility. The Seattle-Tacoma, WA, transit authority is also considering installing a Raytheon PRT system, which the company claims will be a safe, convenient, and affordable alternative to other forms of transportation.



This mockup of a personal rapid-transit system will hold four passengers and run on elevated guideways atop slender pylons.

In addition, Raytheon late last year received a $1.8-million contract from the US Department of Transportation's Federal Highway Administration. Under terms of the contract, Raytheon will study, design, and demonstrate a vehicle/roadway system. The goal is to provide more efficient use of highways by relieving congestion, increasing the number of vehicles traveled per lane mile, and improving air quality. Under the contract, Raytheon and Ford Motor Co's Electronics Division (Dearborn, MI) will act as primary contractors for analyzing tradeoffs, safety concerns, and other issues.

In diversifying into the high-speed rail arena, Raytheon has joined ABB Traction Inc—part of a global company serving the power-generation, industrial, and transportation markets—in a competitive proposal for Amtrak. If the companies win the contract, they will build 26 high-speed X2000 trains for Amtrak's Northeast Corridor between Boston and Washington. ABB Traction in cooperation with Swedish State Railways developed the train, which has been operating in Sweden for three years. Raytheon proposes to manufacture and assemble control electronics, components for the train's tilting coaches, and steerable undercarriages, or "trucks," and to design and build food-service cars for the trains.

The company has also signed a teaming agreement with Kinki Sharyo USA Inc (Wellesley Hills, MA) to bid for the production of 100 light rail vehicles for the Massachusetts Bay Transportation Authority's (MBTA's) Green Line. The vehicles, which will feature low floors to comply with the Americans with Disabilities Act, will replace a fleet

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RAYTHEON STRATEGY

delivered to the MBTA in the late 1970s.

Dual-use technology lets defense contractors share technology between their defense and commercial segments. Raytheon's Beech Aircraft Division is producing both the Beechjet 400A business jet and its military derivative, the US Air Force T-1A Jayhawk trainer on a common production line. This technique helps keep costs down—not just for Raytheon, but also for the military. Raytheon benefits because it avoids having duplicate production areas for nearly identical processes. When differences do occur, employees use tooling to accommodate them. The military benefits because it avoids having to use its resources for basic aircraft development and certification. Further, dual use reduces the risk involved in developing new aircraft and gives the Air Force the modifications it needs to meet its training standards.

By the end of 1993, Beech had delivered 61 Jayhawks to Reese, Randolph, and Laughlin Air Force Bases, and from the initial contract in 1990 until the end of last year, the Air Force has ordered 148 aircraft worth $628 million from Beech. The US program potential is 180 trainers. In addition, Beech has completed manufacturing and certifying three T400 jet trainers for the Japan Air Self Defense Force for undergraduate training of transport search-and-rescue pilots.

To transform the business jet into a military trainer, Raytheon had to modify the commercial cockpit from the two side-by-side positions to a three-position configuration to accommodate a pilot, a copilot/instructor, and an observer. The company also rearranged the cockpit to provide more room for military crews to change positions easily. Additional modifications include cabin-mounted avionics for easier access and maintainability, increased air conditioning for extended training periods, single-point refueling with the ability to permit short turn times and long training missions, and increased protection from striking birds, which happens more frequently at the sustained high speeds and low altitudes of military training sessions.

Despite the differences, the two jets are similar enough to share an assembly line and move through the same production areas, including detail-parts manufacturing and subassembly. Beech also produces another business aircraft, the Super King Air B2000 business turboprop, and its military "twin," the RC-12, on a common assembly line.

The company made another move into dual use with its announcement in June that it plans to produce flat-panel displays for both military and commercial use. The company joined a consortium, which also includes Futaba Corp, Pixel International, and Texas Instruments, to manufacture field-emission displays in the United States.

According to William H Swanson, senior vice president and general manager of the company's Missile Systems Division, the field-emission displays will compete head-on against active matrix LCDs. He claims the field-emission displays offer significant advantages in cost, brightness, and power efficiency. Field-emission displays appear as ¼-in.-thick glass plates that will replace TV picture tubes in aircraft instruments, air-traffic control-tower monitors, and industrial displays.

Not abandoning defense

Despite all the hype about conversion, though, Raytheon and its competitors do not plan to desert their defense business. Indeed, many defense contractors prefer the term "diversification" to "conversion," according to Iridium Inc spokesman John Windolph.

"They don't want to put all their eggs into one basket," he says. "To many, conversion implies an abandonment of their military business."

Raytheon's 1993 annual report backs Windolph's assertion. It lists the company's goals: "to further strengthen established commercial operations, to stay strong in defense, to diversify core defense technologies into commercial markets, and to maintain a strong balance sheet." After all, for defense—and commercial—contractors, a strong balance sheet is the bottom line.

You can reach Senior Associate Editor Fran Granville at (617) 558-4344, fax (617) 558-4470.

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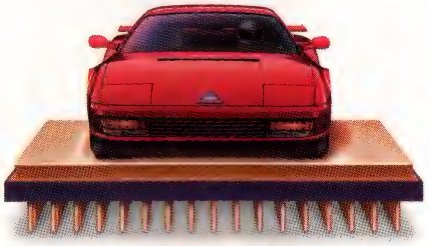

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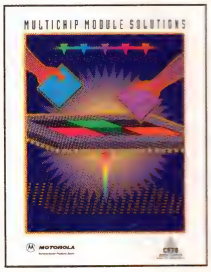

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HIGH-SPEED BIPOLAR PROCESS FORMS BEDROCK FOR WIRELESS ICs

As military-communications business drifts further to the sidelines, one UK-based company sees new and exciting commercial opportunities leap to the fore. Providentially, the new business requires an almost identical set of technologies.

Don't believe that square pegs are always destined for round holes, or that you'll always arrive in the right place at the wrong time. Also, forget depressing stories about military decline leaving contractors nowhere to go. Often things do work out well, "win-win" situations really exist, and former military suppliers can find their talents in even greater demand today.

Such is the experience of the staff at UK-based GEC Plessey Semiconductors, who, with a long service record as prime military communications contractor to the UK's Ministry of Defense (MOD), has seen a new era of demand for commercial wireless products rapidly eclipse traditional communications business.

Wireless technology permeates an increasingly wider range of today's commercial products. Currently, the company's ICs and modules find application in a range of personal-communications products, wireless LANs (WLANs), global-positioning-by-satellite equipment, and intelligent vehicle-highway systems.

An element of good fortune has played some part in bringing about GEC Plessey's business transformation. For, well before it became evident wireless products would be a major growth market, the company already possessed the necessary range of technologies. Essentially, GEC Plessey specializes in microwave and RF, with an in-house armory of 0.7-μm CMOS, RF bipolar, silicon-on-sapphire (SOS), SAW (surface-acoustic-wave) filters, crystal oscillators, thin-film hybrids, and multichip modules (MCMs). Significantly, the company has more than a decade of experience in applying spread-spectrum techniques (**Ref 1**), in addition to extensive volume manufacturing and testing expertise.

But of all the technologies, the company regards its high-speed bipolar process, known internally as "HE," as the linchpin of its entire wireless strategy. Significantly, development grants from the UK's MOD provided some of the funding for this advanced process.

HE is a double polysilicon trench-isolated process that produces high-frequency performance, has low power consumption, and enables high circuit density. The process produces transistors with an effective emitter width of 0.4 μm and a peak fT of 15 GHz at 2.5 mA I_C. The process uses three layers of metallization and achieves high density by allowing contacts over vias.

A significant feature of the process is an ability to include on-chip resistors, capacitors, and inductors. Overall RF performance also relies on polysilicon resistors and the trench isolation structure to minimize parasitic components.

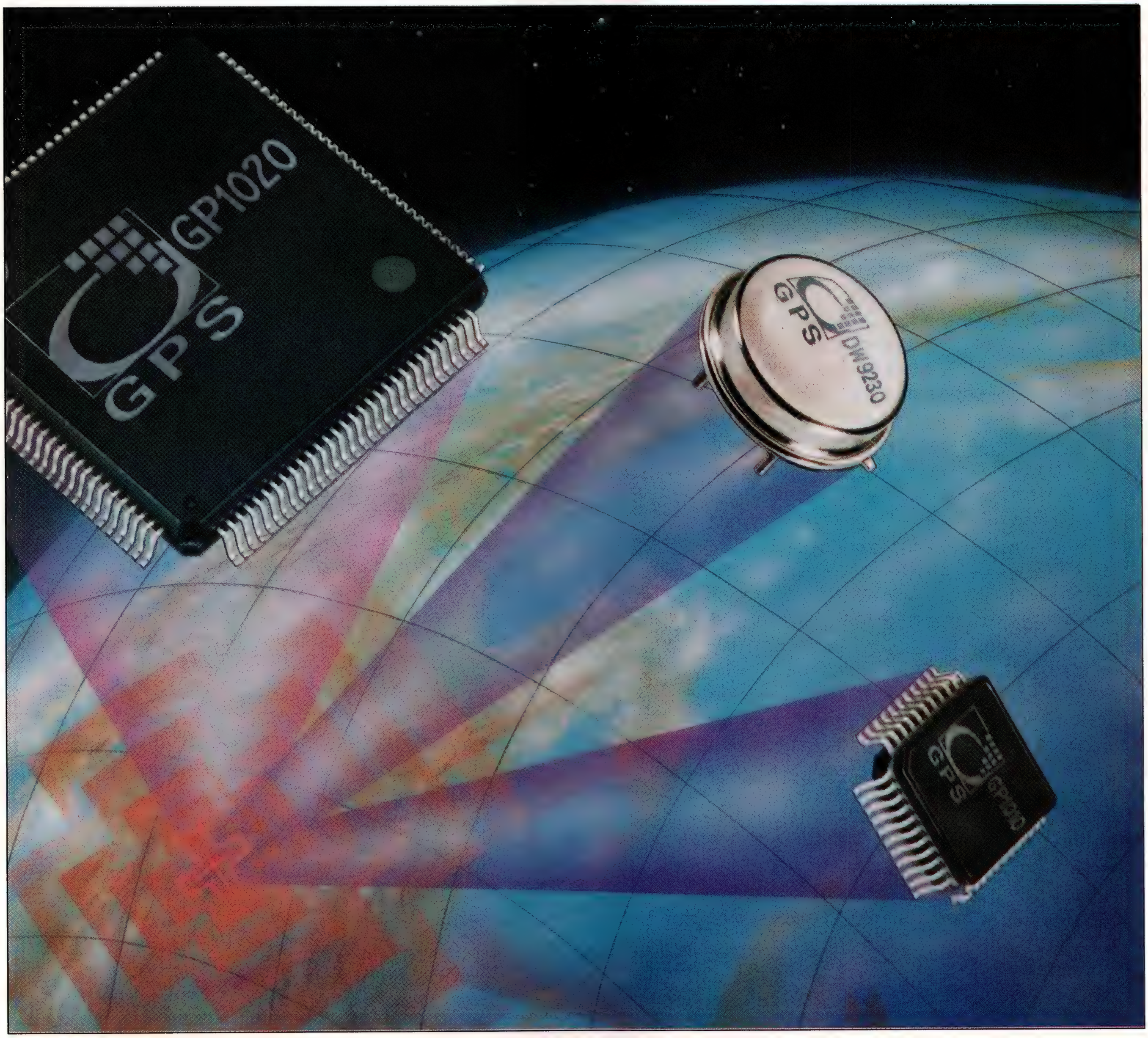
To develop on-chip capacitors, the process introduces a silicon nitride dielectric between two of the metal layers. The high value of the capacitors (0.65 nF/mm^2) enables circuit tuning as well as RF decoupling.

For on-chip inductors, the process uses the top metallization layer. This layer is made approximately twice as thick as the lower layers to reduce resistance and thereby increase the inductors' Q.

Minimizing the number of external components for an RF IC is the hallmark of many GEC Plessey designs. The HE process even provides varactor diodes to enable on-chip tuning of voltage-controlled oscillators. Placing complete RF subsystems on-chip makes the ICs easier and faster to design-in. RF handling of final products becomes more stable and predictable, is less susceptible to external effects, and is less likely to emit spurious signals.

The company's major applications for the HE technology include prescalers for PLLs up to 6 GHz, low-power (15-mW) prescalers, direct waveform synthesizers to 2 GHz, 100-MHz

BRIAN KERRIDGE, SENIOR TECHNICAL EDITOR



GEC Plessey Semiconductors' global positioning by satellite system (GPS) chip set forms the basis of a receiver for GPS coarse/acquisition code or GLOSNASS signals. The GP1010 bipolar receiver front end requires only a DW9255 SAW filter and minimal external components to convert 1575.42-MHz, L1-band spread spectrum signals to 2-bit data for output to a GP1020 CMOS 6-channel correlator.

ADCs, 500-MHz DACs, and integrated radio front ends for cellular, cordless, and global-positioning products.

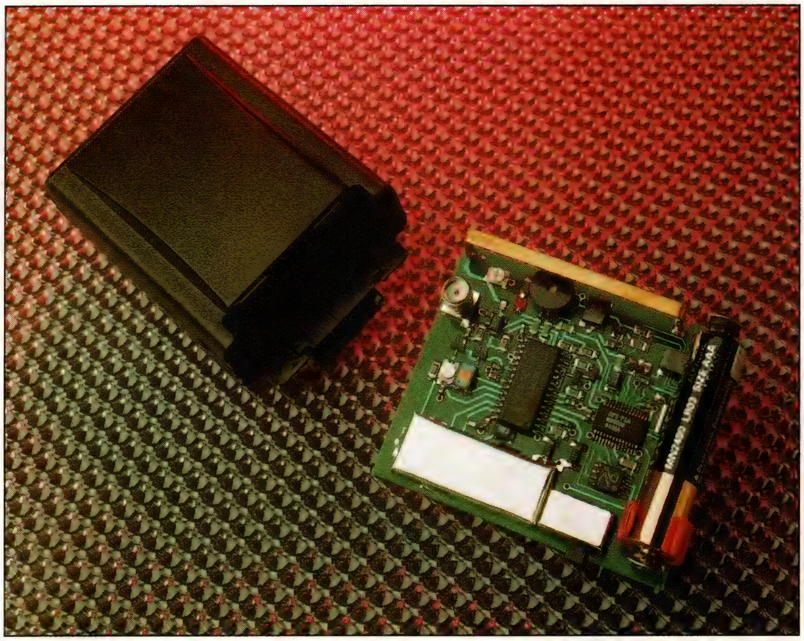
While GEC Plessey holds its bipolar process in high esteem, the company admits that some of its recent RF ICs have now forced the HE process to its performance limits. Also, market drivers, particularly lower prices for automotive electronics and decreasing physical size in the personal-communications sector, constantly apply further pressure to upgrade. In anticipation, the company's next-generation bipolar process—designated "HG"—is set to debut in the next 12 months and will broadly double the speed/power ratio of the process. In parallel with this development, GEC Plessey will follow a path of higher integration through expanded use of MCMs, although the company notes that, currently, MCMs are too expensive for some sections of the market.

Of course, technology alone wasn't responsible for the company's smooth transition from military to commercial wireless business. (In fact, GEC Plessey still serves a wide range of military users.) Gaining success and recognition in a commercial market, however, called for some internal company changes, especially affecting design staff.

Brian Hyde, worldwide marketing manager for GEC Plessey's communication group, identifies time-to-market as the single driving force in bringing about these changes. First, Hyde says the days of projects lasting several years are over. What's more, simply meeting shorter time scales does not guarantee success. In today's business, you need a race mentality because you're always contesting your progress against a competitor's. Also, you need to clearly differentiate your product from others: "me-too" products lead nowhere.

Hyde identifies design tools and staff attitude as two factors that are instrumental in bringing about a race mentality. To reduce design times, GEC Plessey has made substantial investments in EDA tools. And, to improve productivity, a flatter and less formal management structure has brought designers closer to users—and engendered commercial awareness. As further impetus, GEC Plessey designers prefer working with products that support concord in place of conflict. The work is more motivating and satisfying, which, in turn, further raises productivity.

With RF capability to over 2 GHz, GEC Plessey already has major emerging digital-wireless standard frequencies covered (**Ref 2**). Currently, though, the company reports that worldwide analog-cellular business outstrips digital cellular by approximately 10 times, and, despite market hype, that situation will prevail in the short term. The company makes the point that in underdeveloped countries with poor line communications, installing a basic analog cellular system costs less than extending land lines. Digital systems, although offering fancy facilities, work out to be too expensive in these areas. Accordingly, the company plans further integration of its existing analog cellular chip sets.



GEC Plessey Semiconductors' SL6609 bipolar FSK radio receiver requires only an MV6639 POCSAG decoder and a µC to form a pager operating at 512, 1200, or 2400 baud. The SL6609 is a direct conversion receiver requiring no external ceramic filtering. The receiver achieves a sensitivity of –130 dBm and operates up to 350 MHz with adjacent channel rejection of more than 70 dB. Packaging possibilities include PCMCIA cards, credit cards, and wristwatches.

WLANs create major potential

According to GEC Plessey, WLANs represent the company's largest market-growth potential. WLANs are a natural market for GEC Plessey, mainly because of the frequency-hopping spread-spectrum technology requirement. In fact, WLANs became the first commercial application for spread-spectrum techniques, simply because the networks were assigned an unlicensed operating band (2.4 to 2.483 MHz) already occupied by microwave ovens and home and auto radar alarms. Entering the band as a secondary user meant that designs must not interfere with, or be susceptible to, existing signals in the band.

GEC Plessey has progressively refined its DE6003 600-kbps WLAN module over the two years since its introduction. Integration has now reached a physical limit consistent with its low cost of $250 (10,000). The latest iteration suits a PCMCIA format but also allows board space for a user's protocol gate array. The company plans an additional 50% size reduction in an MCM version, although currently cost prohibits its introduction.

Longer-term work on WLANs entails moving to the 5.15- to 5.3-GHz band and increasing data rates to a 20-Mbps payload. This project, known as HiperLAN, involves GEC Plessey in partnership with Apple Computer Europe and Advanced RISC Machines (ARM). The consortium will build a demonstration system with financial backing from the European Commission. The European

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Technical Standards Institute (ETSI) is currently developing the HiperLAN standard. The applications that HiperLAN will open up carry enormous market potential, ranging from office-LAN PC file sharing, email, and printing to video telephony, TV distribution, and real-time remote data acquisition and processing.

GEC Plessey's experience with global positioning indicates a general requirement for a high level of support. These users, for example, in automotive or navigational products sectors, are generally inexperienced in RF-design work. The company has responded by offering RF modules to ease users into the business. More recently, it introduced a Global Positioning by Satellite Builder (GPS-Builder), which is a 12-channel development system on a PC plug-in card ($3950). The product includes the pc-board-layout and software source code to assist users in developing their own systems.

As for the future, in general, GEC Plessey will concentrate on higher levels of integration and lower power consumption in its wireless products, while staying abreast of emerging international standards. The company is quietly keeping watch on future possibilities for commercial satellite communications, knowing full well its in-house SOS capability is ready and waiting. In short, the company simply intends to do more of what it already does well: designing advanced RF products. And, being in the right place at the right time also helps; Europe is the place to be for initiating wireless standards and implementing systems. EDN

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1. Gallant, John, "Digital wireless networks," *EDN*, March 4, 1993, pg 78.

2. Gallant, John, "ICs and modules for digital wireless communications," *EDN*, August 19, 1993, pg 77.

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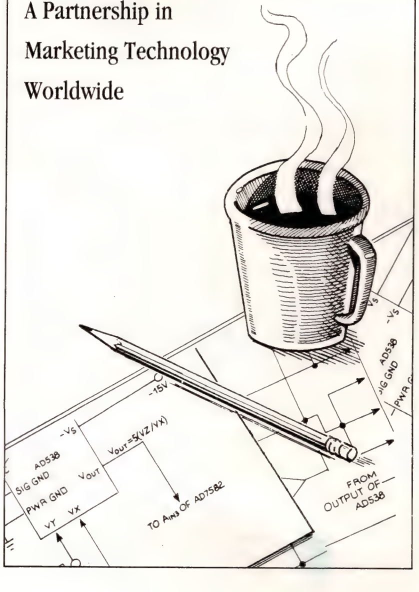

BUILDING A CRADA

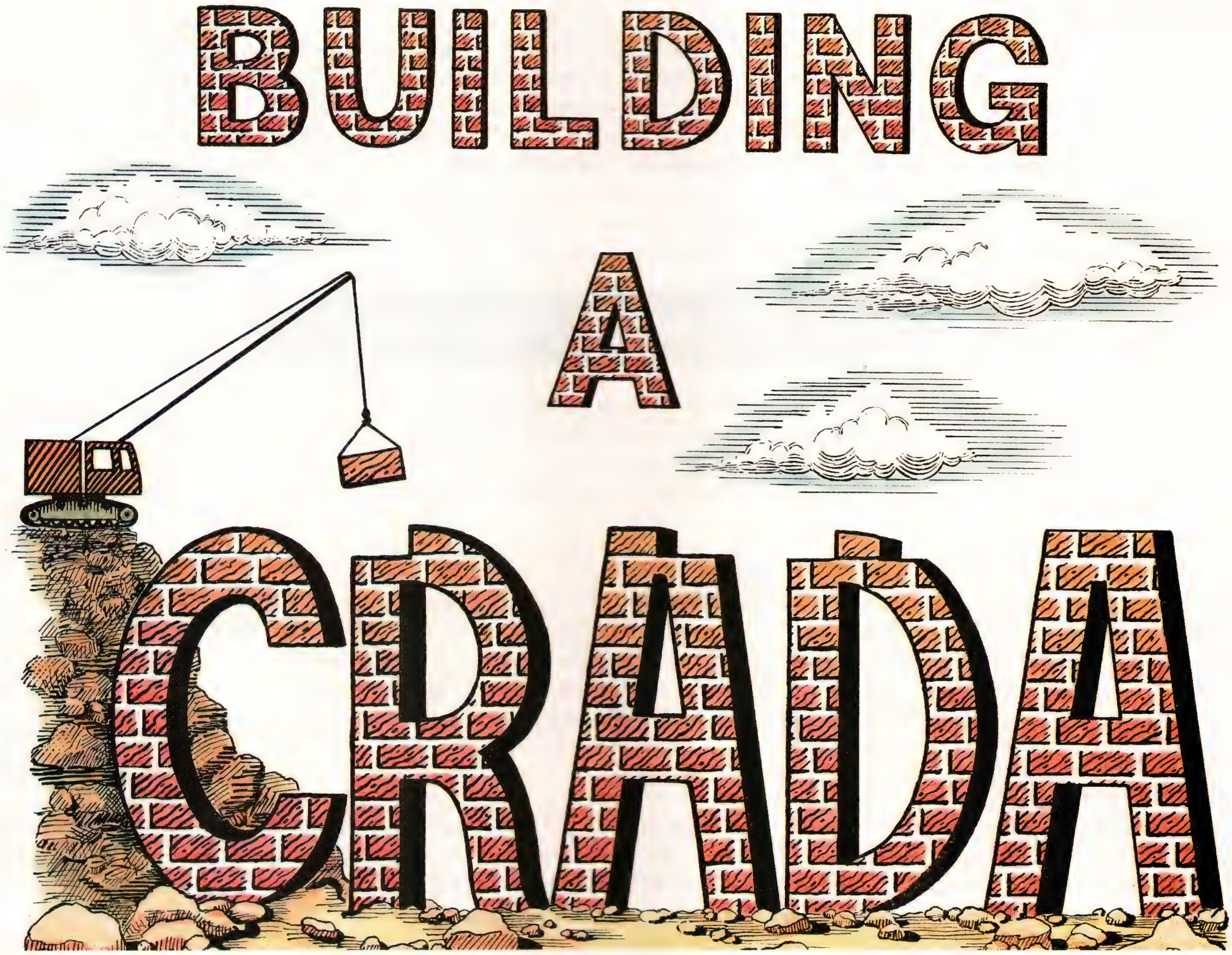

ILLUSTRATION / VIRGINIA PECK

A Cooperative Research and Development Agreement, or CRADA, involving TriQuint and Sandia Labs demonstrates how to become allies in technological breakthroughs.

GORDON CUMMING, TRIQUINT SEMICONDUCTOR,
AND JAMES A HEISE, SANDIA NATIONAL LABORATORIES

Spurred by cutbacks in defense spending and heavy overseas competition, in 1989 Congress initiated a bold step in technology partnerships between the US government (through its National Laboratory System) and private industry. The National Competitiveness Technology Transfer Act enabled Government-Owned, Contractor-Operated (GOCO) laboratories within the Department of Energy (DOE) to enter into the same legal agreements that the Government-Owned, Government-Operated (GOGO) labs within the departments of Commerce and Defense have enjoyed since the mid-1980s.

One of the instruments of technology transfer to come out of the National Competitiveness Technology Transfer Act was the Cooperative Research and Development Agreement, or CRADA. This instrument allows GOCO national laboratories to enter into technological partnerships with private companies and/or universities to enhance US economic competitiveness.

The DOE and Congress have created several avenues for the creation of CRADAs. First, Congress has allocated a portion of defense-program funds for a Technology Transfer Initiative (TTI) program. This program funds proposals after an announced competition and requires matching of funds from partners, either as direct or as in-kind (equivalent research) support. Second, if a specific proposal is in direct concert with existing DOE defense-program objectives, it is possible to form a CRADA as a Weapons Support Agreement. Third, it is possible to form a CRADA based on 100% funding from an industrial partner.

SANDIA NATIONAL LABORATORIES

Established in the 1940s as an outgrowth of the Manhattan Project, Sandia National Laboratories today is recognized as one of the country's most important technological assets. With facilities in New Mexico and northern California, and test facilities in Nevada and Hawaii, Sandia is a multiprogram laboratory with major research and development responsibilities for nuclear weapons, arms control, energy, the environment, economic competitiveness, and other areas of national importance. Sandia's Technology Transfer Program has been focused on technologies in manufacturing, electronics, information, energy, environment, transportation, and health care. Sandia has initiated over 200 CRADAs with a total value of over $600 million.

In addition to the standard CRADA structure, the DOE has established a Small-Business Technology Transfer Initiative at three of its national laboratories—Sandia, Lawrence Livermore, and Los Alamos—and one at the Y-12 plant. This program makes the capabilities of these four facilities available to American businesses having 500 or fewer employees. These labs work with small-business-development centers, cooperative extension services, chambers of commerce, state economic-development agencies, and vocational-education institutions to identify potential technology partners.

DOE CRADAs cover six areas of technological interest: advanced manufacturing and precision engineering, computer architecture and application, energy and environment, materials and processes for manufacturing, microelectronics and photonics, and healthcare technologies.

Each CRADA is an agreement focused on a specific goal or set of goals, and each program is administered separately. Under the terms of the CRADA, the government laboratory can provide research, facilities, and personnel, while the industry partner can provide research, facilities, personnel, and funding. The CRADA agreement spells out all terms and conditions, giving all parties involved a clear indication of costs before the program begins.

The mechanics of a CRADA

Since 1991, the first year of the DOE's legislative mandate, Congress has annually allocated a portion of defense-program funds for TTI-based CRADAs. Proposals are submitted by the four DOE national labs, and CRADAs are awarded on a competitive basis.

For the 1993 call, Sandia National Laboratories—a multiprogram DOE laboratory with a core competency in microelectronics and photonics—and TriQuint Semiconductor—a company that specializes in manufacturing high-performance analog and mixed-signal GaAs ICs—submitted a TTI proposal targeting hardware for high-speed data communications. Realizing that the current 2.4-Gbps limit for fiber-optic data transmission would be inadequate to handle the volume of traffic that the Information Superhighway would be carrying, the DOE funded the joint project. TriQuint and Sandia would develop semiconductor devices to handle the ultrahigh frequencies that a 10-Gbps data rate would dictate.

In an era when most companies are trying to minimize their contact with government, why would a high-technology company want to get involved with a CRADA? In TriQuint's case, R&D funds were an issue: The company knew that it needed to work on a 10-Gbit telecommunications process, but the resources required for small companies to participate in this type of leading-edge, state-of-the-art project are prodigious.

At the time the TTI call for proposals was made, TriQuint was a vendor of Sandia Laboratories for radiation-hardened devices used in the nation's various defense-related programs. As a result of widely publicized Sandia advances in strained-layer semiconductor technology and in the course of doing business, the subject of the telecommunications CRADA arose, and TriQuint decided to pursue an agreement. Negotiations ensued, and in January 1994, CRADA No. 1191 was signed.

The TriQuint/Sandia CRADA has a 36-month duration and a total value of $11,530,000. The technology under development will benefit American industry in general and TriQuint in particular by providing high-speed ICs for current applications, such as optical communications, and future applications, including high-speed optical computer backplanes, high-speed optical commuications for advanced computer architectures, optical switching, and intelligent vehicle highway systems.

Sandia and the federal government will benefit from high-speed semiconductors that will enhance computing speed for the simulation of nuclear weapons and nuclear-weapons systems, semiconductor technology for use in radar applications, and support in microelectronics and photonics core competency. The technology will also provide high-speed amplification, distribution, and switching devices for the Information Superhighway infrastructure and will provide a commercial path through which these parts can ultimately be made available to the consumers in the private sector as well as to DOE defense systems.

Although the CRADA has a very

specific statement of work (SOW) defining each participant's contribution, a CRADA partnership of this type is a dynamic program, not a static one. In traditional government contracts, the award is for a specific program with a definite product in mind. Whether this product is a completed number of aircraft carriers or a $10 component for those aircraft carriers, the process is pretty well-fixed. The CRADA represents an almost total departure from the traditional government-contract structure because it is very flexible. If, at some time during the research, the partners decide that goals must change, either due to some change in the customer's requirement or because of unforeseen technical problems, the changes within the guidelines of the SOW can be implemented by simple modifications to the CRADA legal document by the involved parties under the guidance of the DOE. Straightforward mechanisms are in place if more extensive adjustments are required.

TRIQUINT SEMICONDUCTOR INC

TriQuint Semiconductor was formed in 1985 as a wholly owned subsidiary of Tektronix to continue the investigation of GaAs IC technology started by Tektronix and to manufacture those devices for Tektronix equipment. In 1991, the original TriQuint merged with GigaBit Logic and Gazelle to form the present company.

Triquint supplies high-performance digital, analog, and mixed-signal GaAs semiconductor components to the telecommunications, wireless, and computer/network markets. The company has entered into joint-development and technology-transfer agreements with partners such as AT&T and Sandia National Laboratories to develop future GaAs manufacturing processes. TriQuint has also signed an agreement with AT&T Inc to manufacture wafers using some of these new processes.

The role of the sponsor, that is, the department within the federal government for which the CRADA was established, remains fairly fixed. The roles of the national laboratory and its private-sector partner can change as the program progresses. In the TriQuint/Sandia example, the participants see the roles of each partner changing as the research proceeds in a mutual leader-follower type of relationship. At one stage of the research, one partner might lead, but at the next phase of the program, the other partner might take control, depending on which partner possesses the greatest expertise in each phase of the program.

For all partners involved, the marketplace is the real customer, despite the fact that the DOE is the formal sponsor that provides the matching funds that allow Sandia to participate in the CRADA. This is an implicit admission that the production volumes for many defense-related components are no longer sufficient to keep dedicated producers in business. The beauty of this type of partnership is that the DOE funds the national laboratory's participation, but the result is commercially viable technology for the open market.

Because of Sandia's status as a national laboratory that is government-owned and contractor-operated (in this case, the contractor is Martin Marietta), it cannot be associated with the development, marketing, or volume production of actual commercial products. Sandia's charter is to codevelop technology that can be used by TriQuint to produce marketable products, but this same technology can be utilized by the DoD and DOE for use in any appropriate federal-government program.

Because a CRADA is the formal vehicle for a congressionally mandated program of technology transfer from the public to the private sector, three critical requirements must be met by all applicants:

(1) The agreement must target major national technology goals that are market-driven and industry-defined, with direct benefit for the ultimate systems needs of the sponsoring agency (here, the DOE defense systems).

(2) The agreement must lead to a high degree of collaboration among industry, universities, and federally supported national laboratories, utilizing federal/industrial cost-sharing arrangements to the fullest extent possible.

(3) Fairness of opportunity must be demonstrated, and significant benefit must be demonstrated to problems of national importance and the DOE defense interests.

MORE INFORMATION ON CRADAs

For more information on CRADAs or the Small Business Technology Transfer Program, contact the Sandia National Laboratories' Technology Transfer Centers at (505) 271-7888 in Albuquerque, NM or (800) 294-8358 in Livermore, CA.

Satisfying these requirements isn't as difficult as it might look. Recently, the Semiconductor Industry Association issued a technology plan that would serve the US microelectronics industry through the year 2013. Assembled by 179 top US semiconductor experts from industry, government, and universities, the plan identifies many opportunities for DOE/national-laboratory partnerships with private industry. Similarly, the DOE has developed a critical-technologies list of numerous enabling technologies. Development of these critical technologies will result from advances made by following industry road maps.

The actual CRADA itself can be initiated through a couple of channels. The first step is to contact either the DOE or one of the national laboratories to find out the current status of the TTI program. If the timing or funding of a current TTI is not advantageous, other mechanisms are available for CRADA activity. For work that benefits existing defense-program activities directly, it is possible to form, at any time, either a CRADA with matching DOE program funds or a CRADA in which industry

funds the national laboratories directly. Since many technology goals have been previously defined, the DOE is actively seeking partners in the private sector to begin work on these programs. In these cases, it is necessary only to contact the appropriate national laboratory or laboratories and formulate a proposal.

In some cases, private industry has specific goals that meet criteria No. 1 (above) but of which the DOE might not be aware. In this case, it is necessary to advise the DOE of this fact. The DOE will then review the inquiry and either approve or disapprove it. The negotiation stage of the CRADA varies from agreement to agreement and depends heavily on such factors as the type of technology involved, the private companies involved, previous proprietary technologies or agreements by either partner, as well as the specific goals of the parties involved. If a CRADA is awarded, the document outlines the purpose of the partnership, the benefits to be derived from it, the duration of the partnership, and the financial impact on all parties involved. The CRADA usually takes effect as soon as all parties have signed the agreement.

Clearly, the CRADA is a bold departure for the US government from the types of procurements formalized in the Federal Acquisition Register. In helping US industry stay competitive and, in fact, in many areas, leap far ahead of foreign competition, the government is making the kind of commitment to the future of this nation that many feel should have been its role all along. Certainly, this type of helping hand will be warmly welcomed by private industry in the United States. EDN

Authors' biographies

Gordon Cumming is vice president and general manager for digital communications and signal processing at TriQuint Semi-conductor (Beaverton, OR). He has been active in the semiconductor industry since 1970 and has held management positions at TI, Oki, and the Jet Propulsion Laboratories. He holds a BSEE from Columbia and an MSEE, PhD from the University of Southern California.

James A Heise is a member of the technical staff at Sandia Labs (Albuquerque, NM), where he has been responsible for the design and characterization of digital GaAs ASICs and the design and test of high-clock-rate subsystems that use those devices. He has a BSEE and MSEE from Kansas State University.

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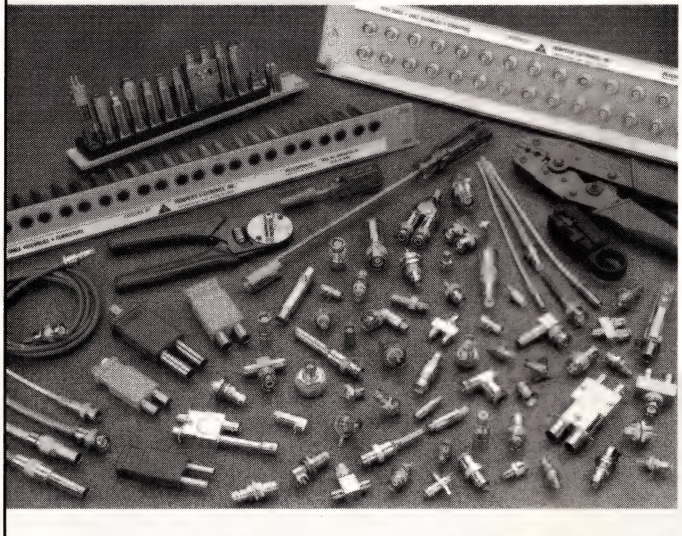

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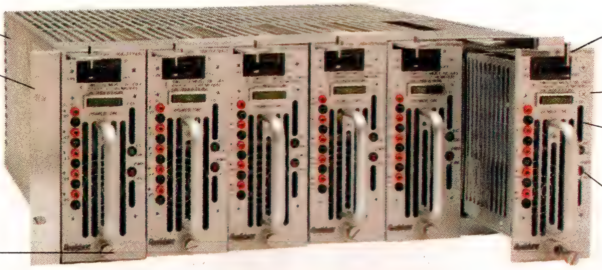
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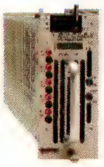
PS-4 Series 7"H x 2.8"W x 19"D 	375 Watts		NA	
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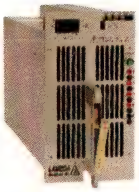
PS-31 Series 10.5"H x 5.6"W x 20"D 	1000 Watts			
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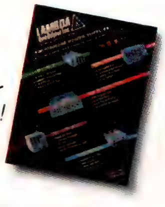

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CIRCLE NO. 66

Israel and America team up for conversion

ALBERTO SOCOLOVSKY, CONTRIBUTING EDITOR

The US Binational Industrial R&D Foundation pairs a US company that is strong in its market with an Israeli company with novel technology.

A remote-controlled drone spying over hostile territory may not have much in common with a news helicopter following OJ Simpson's car on the freeways of Los Angeles or with a sports cameraman covering a fast-moving soccer or hockey game. However, all those scenarios need to transmit and receive images reliably, despite the twists, turns, and shakes of their cameras and the vagaries of their satellite links. Now, they can also share a solution: a digital encoder/decoder developed by the Communications Systems Division of Tadiran Ltd of Israel for that country's military remotely piloted vehicles (RPVs).

The commercial application is digital-satellite news-gathering (DSNG). In a joint binational project, Satellite Transmission Systems (STS) of Melville, NY, a California Microwave Inc company, and Tadiran have adapted the military digital encoder to build a compact exciter (the signal stage of a digital-TV transmitter) and the decoder for a receiver. STS Vice President of Marketing Keith Dunford says that, compared with existing analog links, the new digital solution provides "greater utilization of transponder resources, lower operating cost, and improved [satellite] link performance." He credits the partnership with Tadiran for squeezing the development cycle from two years to only three months. Perhaps more important, he adds, his company's product is not only an example of technology conversion but also a paragon for binational company-to-company cooperation.

This cooperation flew on the wings of the Israel-US Binational Industrial R&D (BIRD) Foundation, a $110-million entity that the two countries endowed 17 years ago. The foundation pairs a US company that is strong in its market with an Israeli company that has novel technology, often developed for a defense application. BIRD uses the income from the endowment, plus royalties it collects from successful projects, to fund half of the development cost of a commercial product. So far, it has contributed to some 400 projects; half of them are paying back royalties. Among the products BIRD has hatched are many high flyers such as Chipcom's LAN controllers, Comsat's satellite-based telephone service, ComStream's satellite data modems, Informix's software, Motorola's μP-controlled irrigation systems, and Tekelec's fiber-optics analyzer. BIRD estimates that its successful projects have generated more that $3 billion in sales for the companies, as well as enough taxes in both countries to have repaid the endowment handsomely.

Aware of the synergy in these binational projects, the governments of both countries now want to build upon BIRD's house. Last January, US Secretary of Commerce Ronald J Brown was in Israel to ratify with his host Micha Harish, Minister of Industry and Trade, the formation of the US-Israeli Science and Technology Commission. Brown recognized Israel's achievements in technology and

The PCMCIA card by Maxtor, the flash disk by M-Systems, and the military-grade disk by Miltope (left to right) are examples of flash-memory technology. Weapons system for the LAMPS MK III helicopter uses flash disks.

compared the influx of technical and scientific talent that immigrated to Israel in recent years from the former Soviet Union with the European scientists who sought haven in the United States in the years before World War II. He identified defense conversion as the opportunity that peace presents to Israel, offering the country "a chance to plow new resources into civilian technology." Yehoshua Gleitman, Israel's chief scientist and a member of the Commission, lists information technology, software and microelectronics, and conversion from defense as areas that will get immediate attention and in which Israel has a lot to offer.

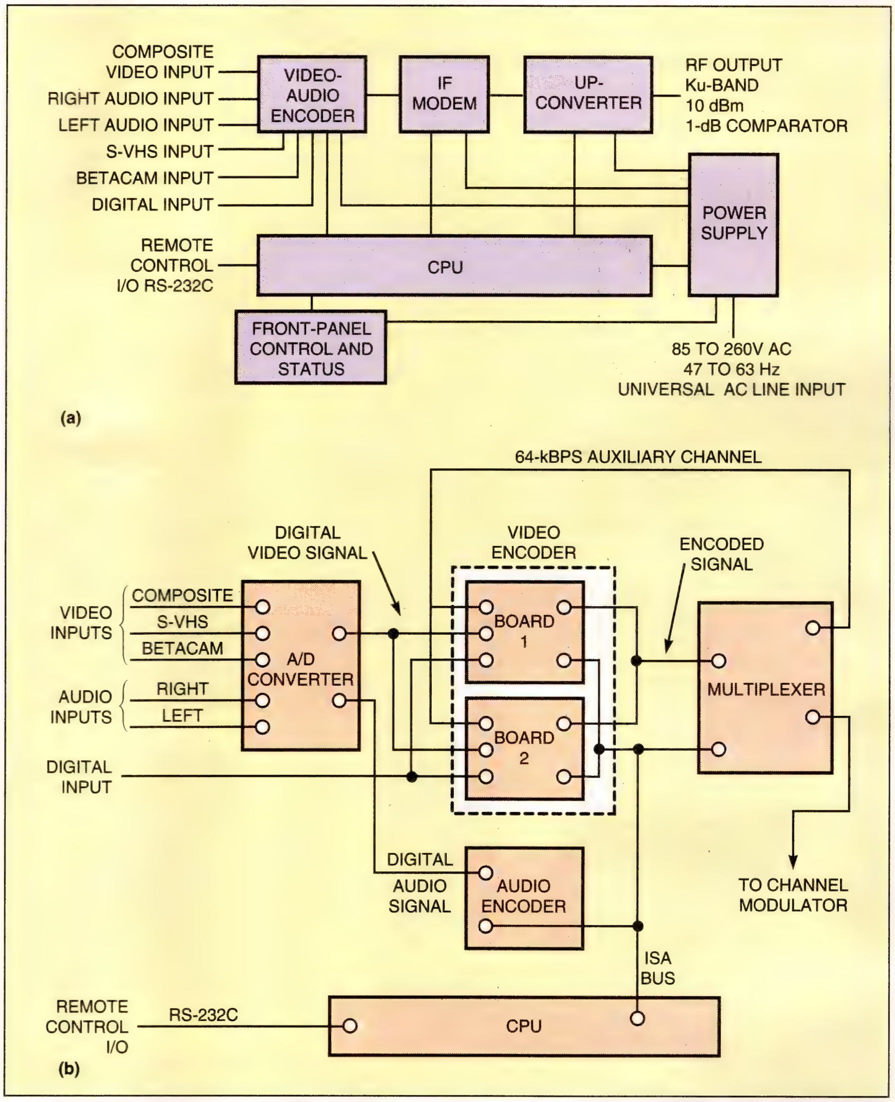
The Commission has called for advice on some top talent familiar with the status of these technologies in both countries. In the United States, they are Craig T Fields, chairman of the Microelectronics and Computer Technology Corp, Joyce Plotkin, executive director of the Massachusetts Computer Software Council, and George M Scalise, senior vice president of National Semiconductor. In Israel, they are Uzia Galil, president of Elron Electronic Industries, known as the country's "Mr. Electronics," Dov Frohman, general manager of chip-maker Intel Electronics, which has designed and made most of Intel's math coprocessors, and David Rubner, general manager of communications-equipment-maker ECI Telecom.

It's about profit

But the Commission has more than a mandate and blue-ribbon names. "It's about profit," says Secretary Brown. He sees it "bringing together some of the world's [finest] minds in ways that will generate new products [that] we will sell to one another and around the world." Elliott Maxwell, director of international technology policy at the Commerce Department's Technology Administration, explains that both countries want to cooperate in conversion because their defense budgets are declining. Maxwell uses BIRD's list of successful projects as examples of technologies in which Israel is strong. "We'd like to get as much information about these technologies to US electronics engineers," he says, "and to expose them to the opportunities in conversion."

Although well-aware of the opportunities, Dunford of STS is skeptical of the role of government. After he discovered that Tadiran had the encoding technology STS needed, he had applied for funds through Advanced Research Projects Agency, under the US government's Technology Reinvestment Project. "But it was rejected, because it's not a world-shattering technology," he complains. He praises BIRD's formula of matching two companies, approving a project, and seeding it with up to $500,000 to each company, moving fast yet without interfering in the development or in the companies' agreement. "[STS and Tadiran] are 6000 miles apart! With BIRD's help, we completed the project in 90 days; government won't even open the proposal in that time!"

Two examples of Israeli-developed defense technology applied to commercial products in the United States—Tadiran's encoder for STS and Gilat's very-small-aperture terminals (VSATs) for GTE Spacenet—are BIRD projects. A third, M-Systems' PCMCIA flash-memory cards for Maxtor, is a direct license. Another example is the work of Elron, a $700-million electronics conglomerate that adopted the US-Israeli binational model as a corporate strategy, investing in both countries and transferring technology between them. It has spawned electronics companies ranging from medical-imaging pioneer Elscint to automated-inspection world-leader Orbotech and chip-maker Zoran.



The encoder in the new STS digital-TV exciter for satellite news-gathering contains Tadiran's spatial error correction that compensates for the TV camera's motion. The company developed the encoder for spy cameras in remote-piloted drones. The IF modem contains Reed-Solomon burst error correction.

Moving camera, steady picture

High-definition TV, the all-digital transmission and reception of TV signals, is still in the future. Until then, when analog transmission is poor, the solution is to digitize the signal. But it takes a lot of bandwidth—about 270 to 500 Mbps—to transmit a digitized 525×60 or 625-line×50-Hz standard signal. Makers of broadcasting equipment use digital compression to reduce the required bandwidth, but the additional circuitry makes the equipment too bulky for news-gathering.

Compression schemes take advantage of the relatively small portion of an image that changes from one TV frame to the next. They save bandwidth and power by encoding and transmitting the portion that changes, instead of the whole picture, and decoding the portion at the receiver. There is very little change in news material and somewhat more in entertainment. The fastest changes are in sports, especially basketball, hockey, and soccer; both the action and the camera move quickly and in all directions.

Less than a year ago, in September 1993, the World Broadcasting Union's (WBU) DSNG Committee issued a report stating the need for affordable, high-performance, compact, and rugged equipment that small vehicles and fly-away terminals could carry. According to Dunford, the Committee expected manufacturers to take two

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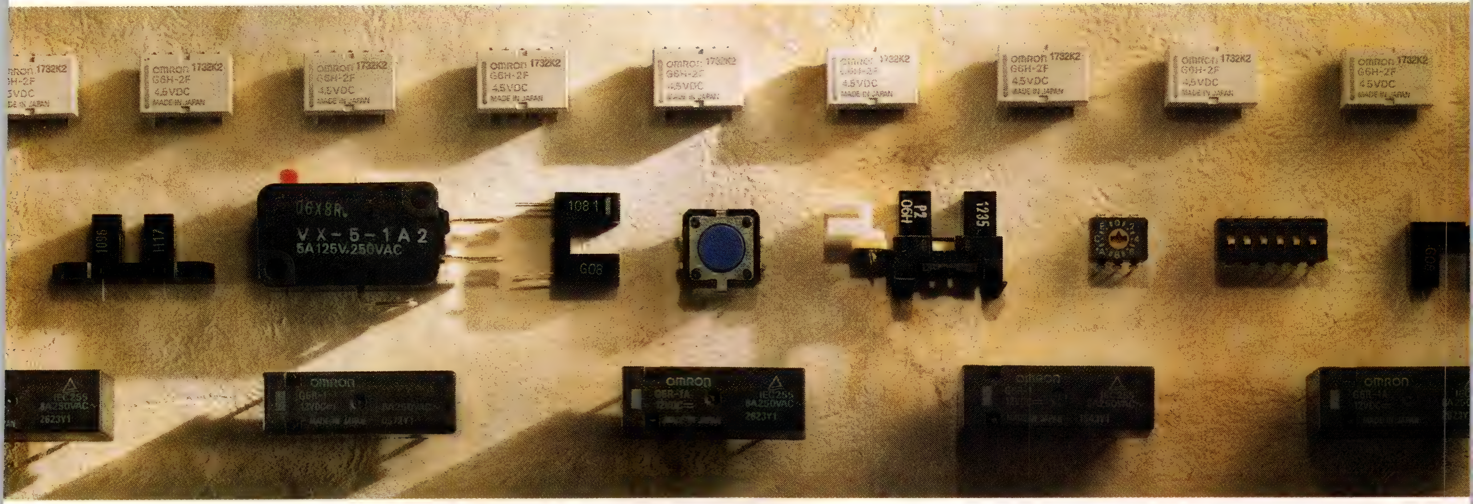

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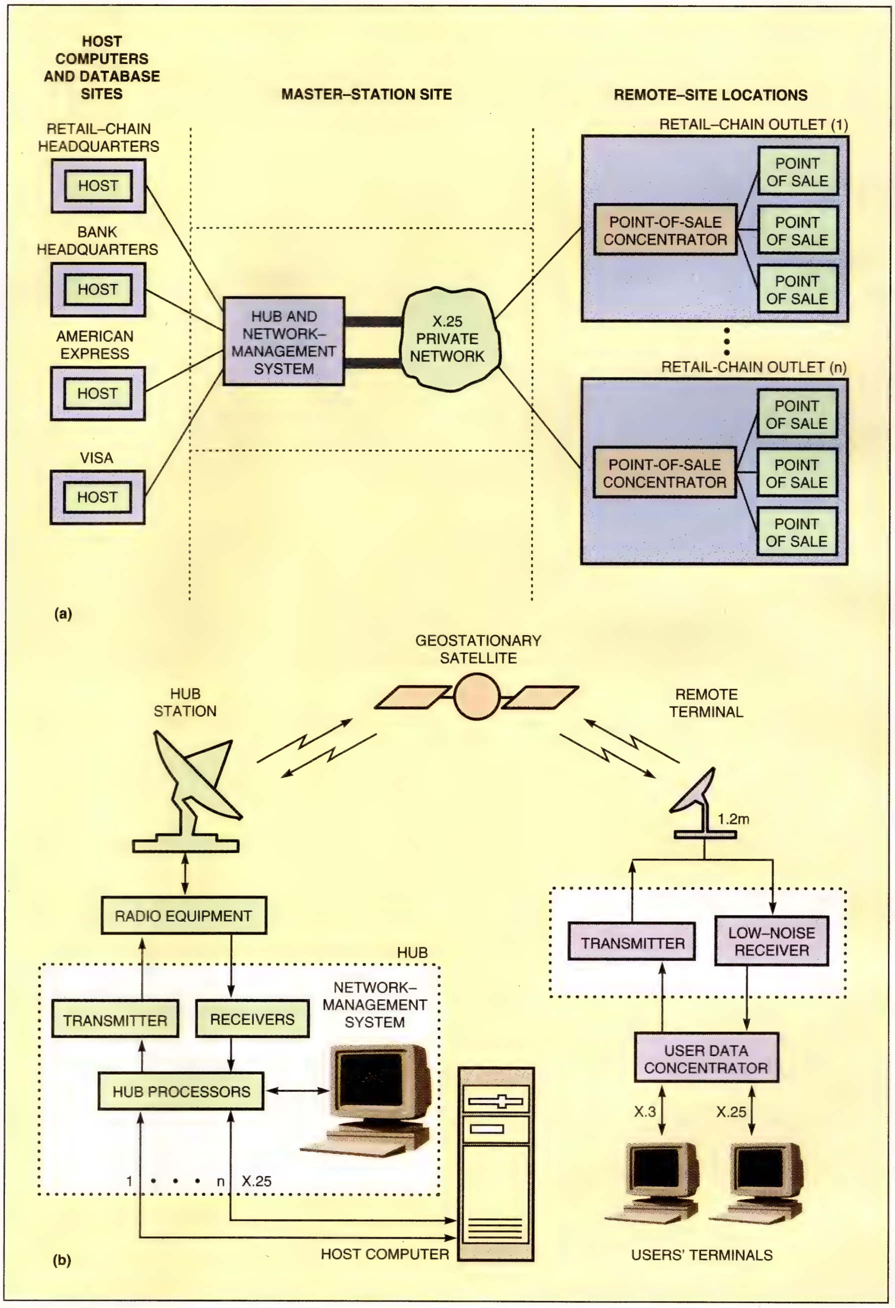


Rite Aid drugstores employ the network architecture of GTE Spacenet's VSATs (a). The VSATs provide transaction processing between a hub and thousands of remote terminals (b). A 1.2m antenna requires two persons to install; the industry is looking to higher carrier frequencies to reduce the antenna diameter and its installation cost.

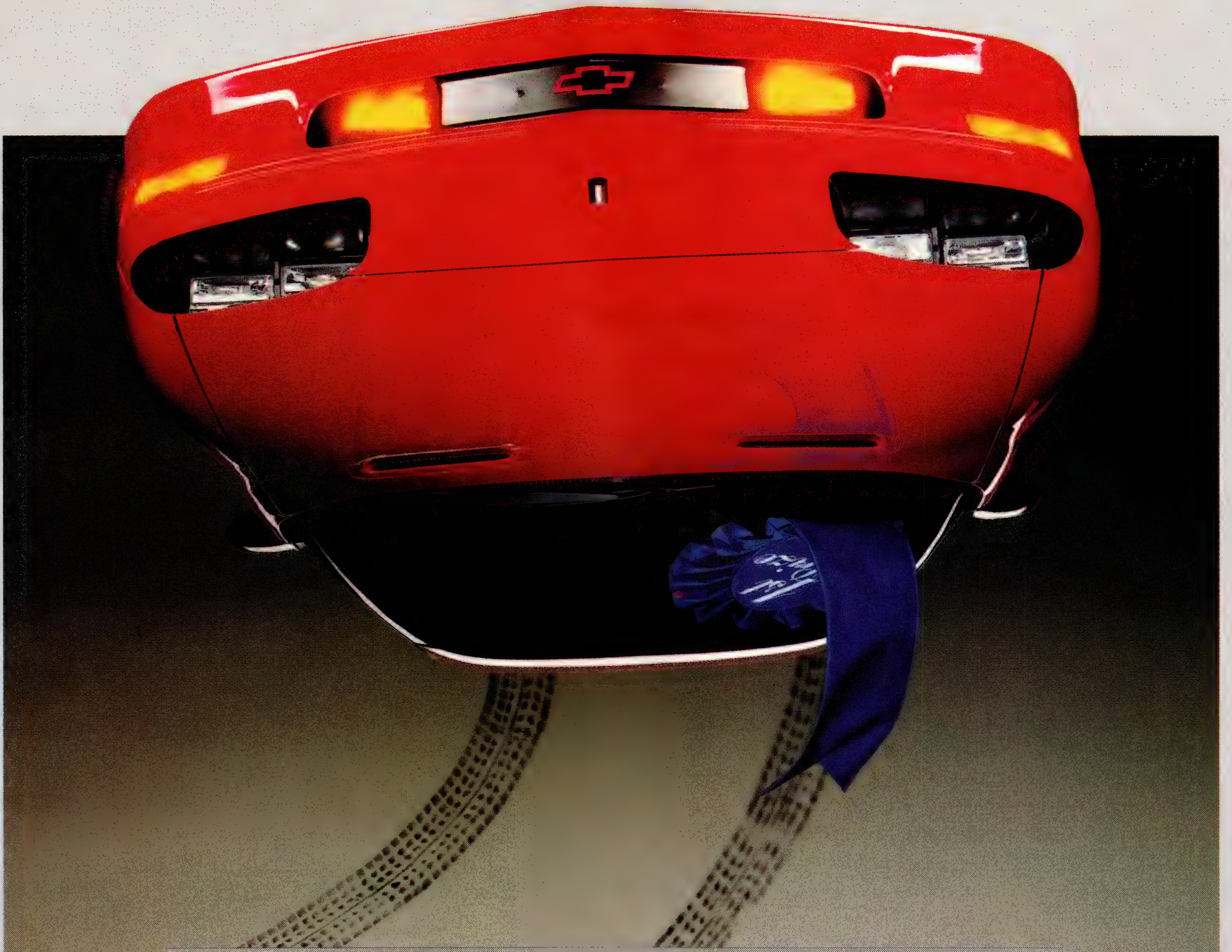
years to come up with the desired equipment. But the solution already existed; Tadiran had developed it for Israel's RPVs. Dunford knew about the solution, and STS was able to address the WBU's need in 90 days.

The ISO's MPEG-2 standards for compressed digital TV signals specify the bit error rate in transmission as 10^{-10}. The standards recommend Viterbi (for block noise) and Reed-Solomon (for burst noise) error correction to achieve this error rate. As it happened, says Ovadiah Cohen, a Tadiran manager involved in conversion of military technology, his company had implemented the very same codes a few years earlier for the RPV cameras, using a chip set by C^3 Microsystems. But these codes protect only against poor transmission and reception. A more serious problem in the military application, the camera's often-jerky motion, required a second level of error correction. Tadiran solved this problem by combining proprietary software and DSPs; it developed a spatial error-correction code that compensates for motion across a wide range of transmission conditions. This code enhances the standard discrete-cosine-transform algorithm used in TV broadcasting to aid the human brain in resolving TV images.

The result is a compact exciter that maintains video resolution of 480×720-pixel (NTSC) and 576×720-pixel (PAL) at data rates from 2 to 8 Mbps. There is no "graceful degradation" in digital-TV transmission, says Dunford; if the equipment cannot maintain video resolution, the signal is lost. Therefore, the design paid particular attention to producing a robust signal throughout the many processing steps—analog-to-digital conversion, encoding, and modulation. The resulting signal, 10 dBm at 2 Mbps, requires only a 50W output amplifier, a big improvement over the 300W power amplifier needed for analog transmission.

A smaller, lighter, lower cost transmitter would be welcome, says Mike Hurt, director of American Broadcasting Co's satellite-TV communications, who hasn't seen the new STS products. The space it would save in SNG trucks isn't a big factor, he cautions, because these trucks must carry technicians and heavy tape-editing equipment. So far, he adds, "we haven't seen any digital [SNG] system cheap enough and good enough to replace the analog." Dunford trusts his new exciter and receiver are meeting both conditions and that the savings in bandwidth and in transponder resources will be worth the switch to DSNG.

One of the largest electronics companies in Israel, Tadiran has been working for the past four years with US companies in harvesting its huge portfolio of clever solutions developed for defense. A well-known example is the base stations and car units it makes for the Pacific Telesis TeleTrack vehicle-identification and -location system for



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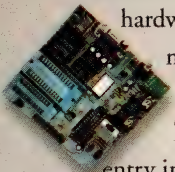

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urban areas, which operates in Dallas, Detroit, Los Angeles, and several other cities. This system, based on a directional locator for military vehicles, operates on triangulation and spread-spectrum technique. L-band transmission uses dozens of high-altitude antennae, resembling a terrestrial global positioning system (GPS). Tadiran has now perfected a system for automatic toll collection at full highway speed. It comprises high-frequency antennae and readers for the toll gates and smart cards for the cars. The system can identify the correct toll and vehicle for vehicles traveling as fast as 100 mph.

A solid-state hard disk

The "M" in M-Systems used to stand for "military." The Israeli company has now added "Flash Disk Pioneers" to its name, after its main developments, a flash memory that emulates a hard disk, and PCMCIA flash-memory cards. The advantages of semiconductor flash memory over its solid-state predecessors—RAMs, ROMs, EPROMs, and EEPROMs—are simplicity (thus, potentially lower cost) and nonvolatility. The application for flash emulation of hard disks is still mostly military. Helicopters and tanks, for example, are too harsh an environment for the delicate rotating mechanisms of a magnetic hard disk.

For this application, M-Systems developed software called TrueFFS (flash file system), which emulates a hard disk and removes some of the limitations of earlier FFS. M-Systems uses this architecture in the flash-memory boards that the company supplies to Miltope of Melville, NY. IBM's (now Loral's) Federal Systems Division has selected Miltope to supply flash-memory disks for the weapon system that Loral is building for the US Navy's LAMPS MK III. Miltope makes military and industrial flash disks storing up to 230 Mbytes. A military-grade 80-Mbyte disk, for example, lists for $28,000.

Flash memory is still too expensive to compete with high-capacity disks outside the military market. Still, there are industrial and embedded applications, particularly for PCMCIA memory cards, which need the ruggedness of flash memory but require less than 10 Mbytes. Since manufacturers no longer make mechanical hard disks at such small capacities, flash replacements are becoming affordable, even though their cost per bit is still high.

Maxtor sells a line of flash PCMCIA cards with capacities up to 20 Mbytes, which the company developed with M-Systems. The 8-Mbyte card lists for $581, slightly more than a 105-Mbyte PCMCIA hard drive. The companies are aiming these cards at mobile, low-power computer applications. Prices for flash memory will go down with the cost of flash chips, says Rod Watkins, industry analyst at market research company Dataquest. He reasons that, in the long run, the inherent materials cost of flash PCMCIA cards—chips and printed card—will be lower than that of the spindle motor, rotary drive, and magnetic head of hard disks. In the meantime, flash PCMCIA cards must also bear the extra cost from the software to emulate or mask the organization of magnetic disks, as well as to compensate for some of the electrical problems of flash-storage cells.

Tadiran has now perfected a system for automatic toll collection at full highway speed.

Cheap bit talk by satellite

You can see them atop the roof of any Rite Aid drug store. The small antennae stare silently at a fixed point in the sky with their 3- to 6-ft white dishes, as they send and receive bursts of data inexpensively over the Ku band. The US' largest drugstore chain uses GTE Spacenet's "Skystar Advantage" satellite-communications service to relay data from its millions of data transactions—from inquiries and inventory to point of sale and prices—between its data-processing hub and thousands of stores across the country, at a cost lower than possible with leased telephone lines. GTE Spacenet, for its part, can better use its satellite links and provide more value-added services to customers such as Rite Aid, thanks to Ku-band VSATs made by Gilat Communication Systems of Israel. The satellite is in a geostationary orbit, giving the antennae a line of sight to the satellite. The hub antenna can adjust to minor changes in the satellite's position, and the small antennae at the branches rely on a slightly broader beam.

Because there is plenty of channel capacity in geostationary satellites, GTE Spacenet is now trying to increase the amount of data it transmits and the services it provides to its customers. The Gilat terminals, which incorporate low-noise communications equipment operating in the Ku band (10.95 to 12.75 GHz), data processing, and storage, become important components in implementing GTE's strategy.

Unlike other cases of conversion described here, VSATs were developed neither in Israel nor for a military application. They were developed in the United States to provide communications to remote Alaskan villages. Israeli engineers have contributed their expertise in spread-spectrum techniques and software. Spread spectrum is an information-science technology used in military communications to render a secure transmission insensitive to enemy or atmospheric interference; in the Rite Aid application, it minimizes interference from adjacent antennae. Gilat's software optimized the data equipment for transaction processing, which typically comprises short, discrete bursts of data. This software includes network management, protocol conversion, and diagnostics.

Last month, GE American Communications agreed to purchase Spacenet from GTE. "The purchase will establish Americom in the fast-growing VSAT business," says Chairman and CEO John F Connelly. "We are impressed by Gilat's familiarity with—and contribution to—Spacenet's VSAT business."

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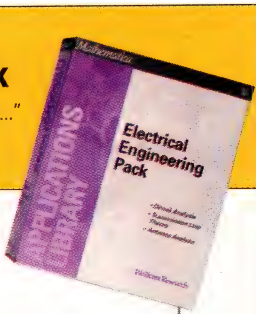

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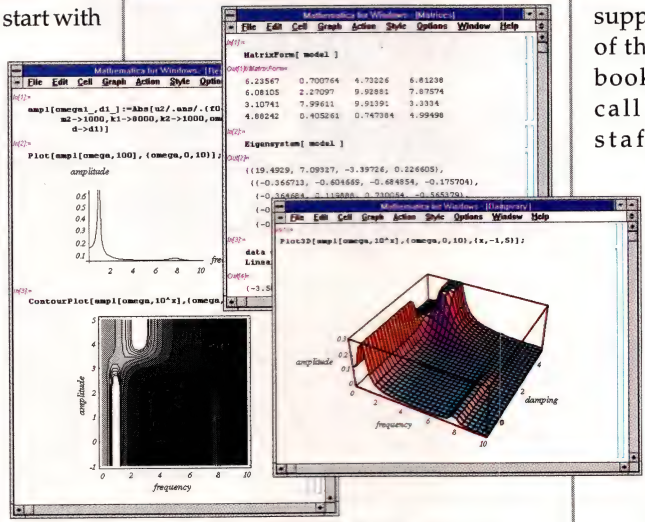
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amplitude
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-1
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2
4
6
8
10
frequency
0.3
0.2
0.1
0
amplitude
frequency
damping

```
In[1]:=
ampl[omega1_,d1_]:=Abs[u2/.ans/.{f0
     m2->1000,k1->8000,k2->1000,om
       d->d1}]
In[2]:=
Plot[ampl[omega,100],{omega,0,10}];
In[3]:=
ContourPlot[ampl[omega,10^x],{omega,
```

```
In[1]:=
MatrixForm[ model ]
Out[1]//MatrixForm=
 6.23567    0.700764   4.73226    6.81238
 6.08105    2.27097    9.92881    7.87574
 3.10741    7.99611    9.91391    3.3334
 4.88242    0.405261   0.747384   4.99498
In[2]:=
Eigensystem[ model ]
Out[2]=
{{19.4929, 7.09327, -3.39726, 0.226605},
 {{-0.366713, -0.604669, -0.684854, -0.175704},
  {-0.364684, 0.119888, 0.730054, -0.565379},
  {-0
  {-0
In[3]:=
data
Linea
Out[4]=
{-3.5
```

```
Plot3D[ampl[omega,10^x],{omega,0,10},{x,-1,5}];
```

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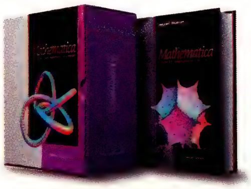

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CIRCLE NO. 89

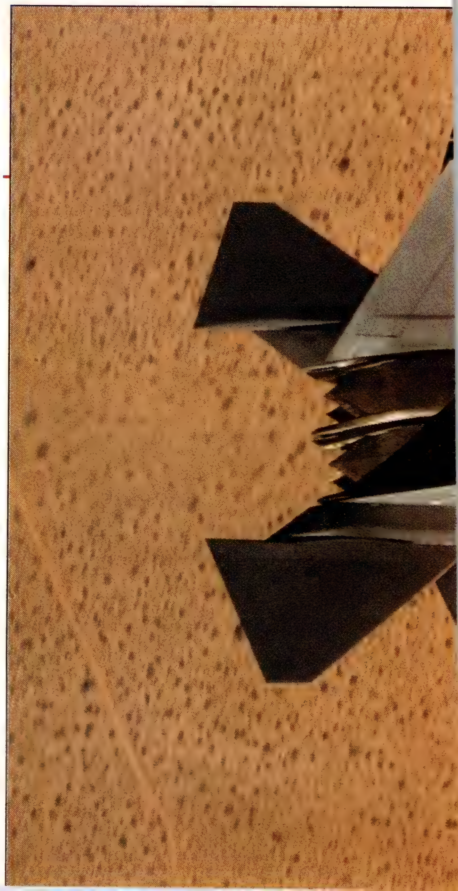
VHDL emerges as a commercial design tool

Despite the initial challenges imposed by VHDL, the language, born of the military, has made the commercial sector sit up and take notice.

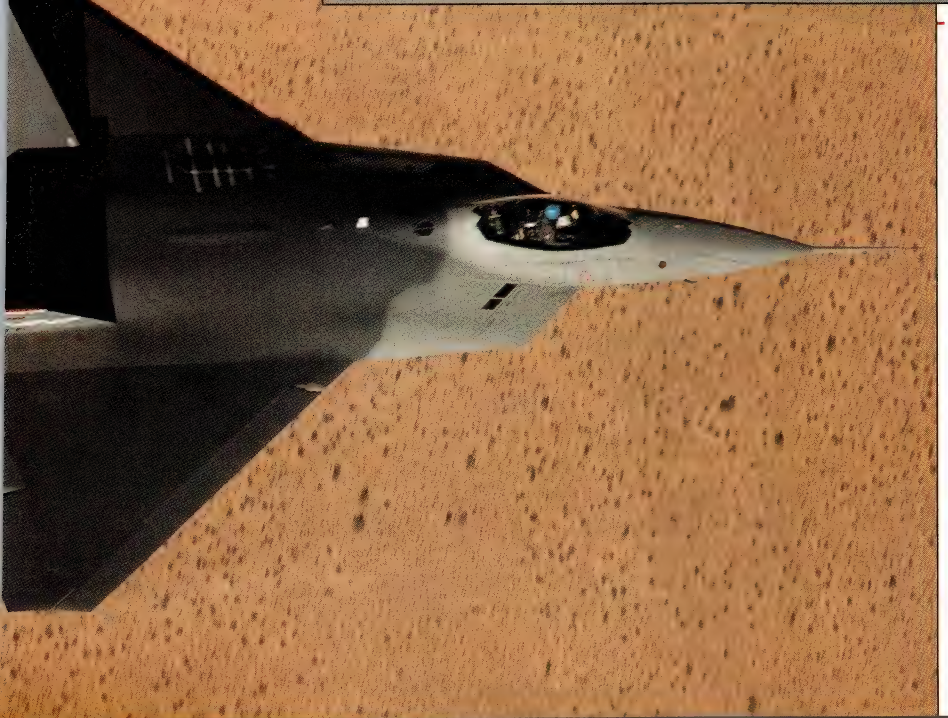
KAREN BARTLESON
United Technologies Microelectronics Center

More than 10 years ago, the US Department of Defense (DoD) funded a project under the VHSIC (very-high-speed integrated circuits) program to create a general circuit and a hardware-description language. The DoD wanted to preserve its designs with a strong documentation facility and use a common design methodology. The result of the project was the creation of VHDL, or VHSIC hardware-description language. It provided government contractors with a standard communication method that facilitated top-down design techniques. It also addressed the concern of how to upgrade systems when technologies became obsolete.

Similar to a programming language, VHDL has constructs that represent sys-



VHDL was fundamental in the design of the interfaces for the F-22 advanced tactical fighter.



tems, networks, and components. The language provides the ability to describe these at a very high (general) behavioral level as well as very low (detailed) gate levels. People now interpret the term "VHDL" to also include a design methodology and environment.

Development of VHDL began in 1983 with a joint effort by IBM, Texas Instruments, and Intermetrics under the VHSIC contract. Each company brought its experience with high-level languages and top-down design to the forum. The companies developed the language and tools for simulation in parallel during a multiphase effort. Custom ICs developed under VHSIC used VHDL as a proving ground.

Initially, VHDL was slow to catch on. The IEEE ratified VHDL as Standard

VHDL 1076 in December 1987, and in the same year the DoD mandated that all circuits be described through the process. This mandate, MIL-STD-454, required that companies manufacturing digital ASICs after September 30, 1988, document them by means of structural and behavioral VHDL descriptions in accordance with IEEE Standard 1076. Even then, the government continually granted waivers against the requirement because of limited availability of tools and expertise.

Because knowledge was scarce and training was insufficient, a general lack of understanding existed within the design community. As such, tools for creating and simulating designs in VHDL were not in demand, and vendors were not compelled to produce them.

Further, top-down design was a major revolution in the techniques to engineer circuits. The jump from logic gates to abstract behavioral descriptions was akin to the jump from transistor- to logic-level (Boolean) design. It always takes awhile for a new design methodology to be proven and accepted. Brave designers, standardization, and government mandates were the catalysts for VHDL growth. Improved tools followed, and the field of logic synthesis fueled VHDL's expansion.

The F-22 advanced tactical fighter was one of the first major government programs that forced across-the-board use of VHDL descriptions for all subsystems in the project. The interfaces on the F-22 were tightly coupled, and their coordinated communication was crucial. The designers used VHDL not simply as a documentation vehicle, but as a fundamental part of a top-down design strategy. This breakthrough project helped establish VHDL as a viable, useful tool for electronic-system and -subsystem designers working on government military projects.

The advantages of VHDL

VHDL provided the government with several key advantages. Possibly the most important was the ability to perform top-down design. Top-down design first describes a system at a very high level of abstraction, like a specification. Designers simulate and debug the system at this very high level before refining it into smaller components. The method describes each smaller component at a high level and debugs it alone and with the other components in the system. The design continues to be refined and debugged until it is complete down to its lowest building blocks. Mixed-level design occurs when some components are at a more detailed level of description than others, but all components are simulated and debugged together. VHDL aims to provide a way of describing and simulating the system and its components. **Listing 1** shows a sample of VHDL that describes a generic counter and a 16-bit counter built from it.

The power of top-down design is that engineers can discover and correct system problems early in the design cycle. They can design and fine-tune component interfaces before completing the actual components. They can simulate components as part of the system before making a silicon commitment. Experts estimate that 90% of all ASICs work right the first time on their own, but only 50% of them work right the first time in the system. Top-down design with system simulation can improve the success rate of the system. Further, software designers can develop system software without waiting for hardware availability. The bottom line is lower cost and faster time to market.

During the years that designers were creating VHDL, digital designers were manually refining top-down design procedures from high-level descriptions to logic gates. The field of logic synthesis was still experimental. Logic synthesis describes a circuit at a high level in a language such as VHDL and then uses a software tool that automatically generates the logic-gate implementation for the design. This advanced technology can significantly speed design because engineers spend less time producing logic-gate representations and can concentrate on overall design issues, such as system requirements and timing. Synthesized designs can be smaller and faster than manually created ones, and smaller designs usually mean lower cost. Synthesized designs also can cut debug time because the designs are generally "correct by construction." As logic synthesis emerged as a mainstream technology, VHDL fit in perfectly as a language to begin synthesis.

LISTING 1

```
entity UPCNT is
   generic( L : integer := 1 );
   port( CLOCK, WB, ENABLE      : in  std_logic;
         DIN          : in  unsigned(L-1 downto 0);
         DOUT         : out unsigned(L-1 downto 0));
 begin
    assert (DIN'Length = DOUT'Length)
    report "Input DIN must be the same width as output DOUT"
    severity Failure;
end UPCNT;

architecture BEHAVIORAL_VIEW of UPCNT is
        subtype InBits  is Natural range DIN'Length-1 downto 0;
        subtype OutBits is Natural range DOUT'Length-1 downto 0;
        signal State  :  unsigned(OutBits);
begin
    DOUT <= State after COMB_DLY;
    State <= DIN     when WB='0'     else
          State+1 when CLOCK'event and CLOCK='1' and ENABLE='1' else
             State;
end BEHAVIORAL_VIEW;


entity UPCNT16 is
 port( CLOCK, WB, ENABLE : in  std_logic;
   DIN          : in  unsigned (15 downto 0);
   OE2           : in  std_logic;
 DOUT1,DOUT2  : out unsigned (15 downto 0));
end UPCNT16;

architecture BEHAVIORAL_VIEW of UPCNT16 is
  component UPCNT
  generic( L : integer := 1 );
  port( CLOCK, WB, ENABLE : in  std_logic;
        DIN              : in  unsigned(L-1 downto 0);
        DOUT              : out unsigned(L-1 downto 0));
  end component;
  signal CNT : unsigned (15 downto 0);
begin
  DOUT1 <= CNT;
  X_1 : UPCNT generic map( L => 16 )
               port map( CLOCK, WB, ENABLE, DIN, CNT );
  DOUT2 <= CNT after COMB_DLY when OE2='0' else
      (others => 'Z') after COMB_DLY;
end BEHAVIORAL_VIEW;
```

Another important advantage that VHDL brought to the government was standardization. It enabled manufacturers to document all electronic systems and components in a common format, which allows various interested parties to understand and participate in a system's development. VHDL also provided the ability to capture designs in a standard format for archiving.

Additionally, VHDL afforded vendor independence for government procurement officers, designers, and contractors. VHDL also enabled a program's design phase to begin before hardware vendors won contracts through bidding

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CIRCLE NO. 85

and negotiation. Second-sourcing was more straightforward and less risky than with other methodologies. Designers could map designs from one foundry to another, from one technology to another (such as from field-programmable gate arrays (FPGAs) to mask-programmable gate arrays), and from old technologies to modern ones. Designers could also realize independence from tool vendors in the EDA industry. They could match synthesis tools from one vendor with simulation tools from another to create a cost-effective and flexible system to meet a project's needs.

VHDL FILLED SUCH AN IMPORTANT NEED THAT THE COMMERCIAL SECTOR TOOK NOTICE.

VHDL did not come without challenges, however. The first obstacle was the learning curve required for the new technology. Circuits now looked like software instead of hardware. Designers had to overcome their fear of this strange way to create a circuit. ("If I had wanted to be a programmer, I would have studied computer science!") Some argued that VHDL was cumbersome and not intuitive. The early VHDL simulators were so slow that doing actual design work with them was impractical. Migrating designs into a VHDL environment took time, and there were few tools to help. Even though VHDL was a standard, vendors supported different subsets of the language, and designs were not completely portable. Interoperability among tools and other hardware-description languages imposed restrictions. Gate-level simulators and design kits were few and had limitations. Many of these issues persist, though vendors and alliances are working toward solutions.

Despite its challenges, VHDL filled such an important need that the commercial sector took notice and brought it into a productive design technology.

Shift to commercial applications

Intense competition among commercial design houses promoted top-down design methodologies. A robust language for describing electronic systems and circuits was a cornerstone to top-down design, but without a capable simulator, a language alone had limited value. In the mid-1980s, small start-up Gateway Design Automation created a solid language and a premier simulator to accompany it. The language was Verilog Hardware Description Language, and the corresponding simulator was Verilog-XL. Gateway held the rights to the language and sold many licenses of the impressive simulator. When Cadence Design Systems acquired Gateway and the rights to Verilog HDL, it released Verilog HDL into the public domain in May 1990. Designers using Verilog HDL continued to be captive to a single supplier until recently when Verilog-based tools began to appear on the market from additional sources.

When VHDL received IEEE standardization and was readily available to everyone, the attraction was great to provide competition to the Verilog language and offer freedom of choice to the design community. Some EDA vendors saw an opportunity and developed design tools around VHDL. The availability of usable tools actually drove VHDL's success in the commercial world. Today, tools that support both VHDL and Verilog HDL abound, and the VHDL-vs-Verilog debates have become almost religious in nature. It appears that vendors are settling in to support both as viable languages for the future.

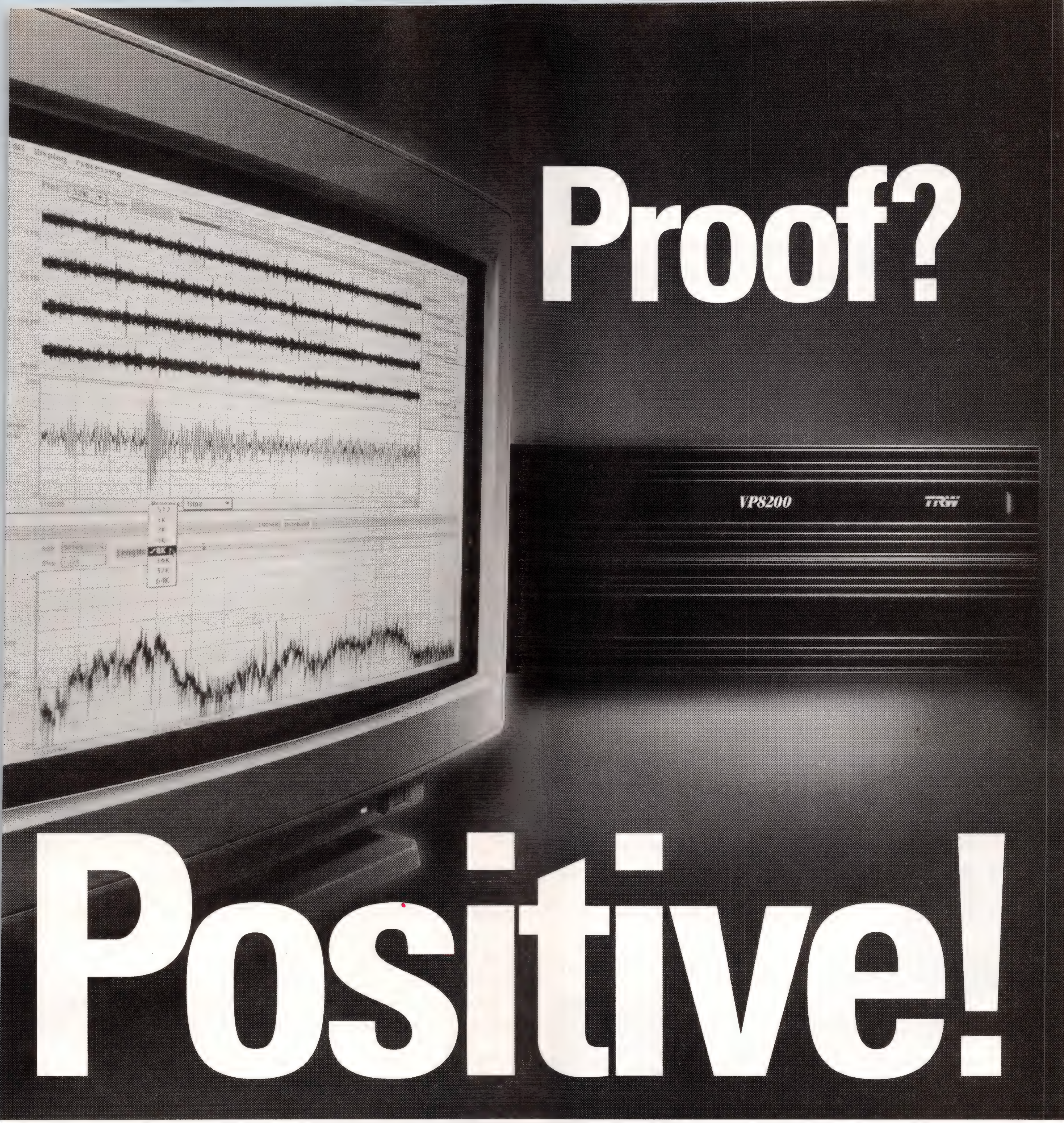
The advent of logic synthesis further accelerated VHDL growth. Designers began using synthesis in increasing numbers to produce very large and complex circuits in relatively short amounts of time. VHDL also became very popular in Europe, another example of a US government effort that has found global interest and value.

A language with a purpose, VHDL proved its worth on major commercial endeavors. At Hewlett-Packard's Boise R&D facility, engineers used VHDL for top-down design of components for the company's popular LaserJet printers. Alcatel's Radiotéléphone Division in France used VHDL to develop ASICs and software for its mobile telecommunications equipment. Minnesota-based Ancor Communications performed VHDL top-down design and logic synthesis for its single-chip Fibre Channel Standard solution.

VHDL's future appears to be solid. It continues to gain support from commercial and military vendors and designers. The DoD mandate for designs to be documented in VHDL has become a fact of life, and few government programs do not call for VHDL usage during some phase. The increasing complexity of today's commercial circuits and the improvements in logic-synthesis tools will make VHDL commonplace. EDA vendors are working to produce synthesis tools that will work at ever-higher levels of abstraction in the VHDL language.

The ASIC market is helping to further VHDL usage. An initiative that is gaining momentum and acceptance is VITAL, the VHDL Initiative Toward ASIC Libraries. VITAL is an organization of designers, ASIC vendors, and EDA vendors that is dominated by commercial companies and interests. The organizers formed VITAL to address the lack of ASIC libraries for VHDL design and missing standards that would make library production and support easy for ASIC and EDA vendors alike. ASIC libraries that are readily available and compatible among design tools will further encourage designers to use VHDL.

As designs progress into even greater levels of complexity, design reuse is becoming practical. Designers can readily drop smaller designs and complex modules described in VHDL into larger designs. Vendors have sprung up that sell VHDL models of various standard parts, from logic gates to microprocessors. It is not unusual for a customer to demand a VHDL model to accompany a hardware purchase.



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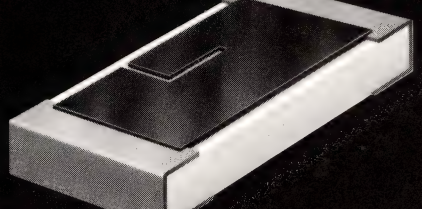

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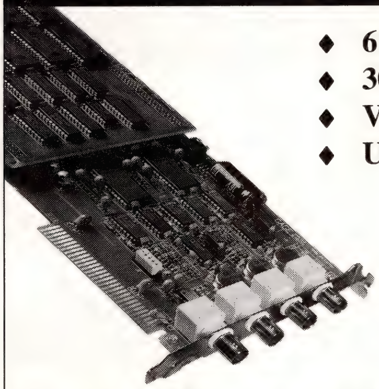

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CIRCLE NO. 27

VHDL

VHDL will continue to receive support from standards bureaus and organizations. As part of continuing IEEE certification, VHDL must be revisited and revised at least once every five years. VHDL 92 was the first revision performed for the IEEE 1076 standard. Current investigation into standard packages for simulation and synthesis will improve the interoperability of tools and promote common design practices.

VHDL International (VI) is an alliance of companies, universities, and individuals whose purpose is to cooperatively and proactively promote VHDL as the standard worldwide language for the design and description of electronic systems. Its organizers founded VI in June 1991, and its membership and visibility continue to increase. VI holds regular, international forums to educate users and to advance the language.

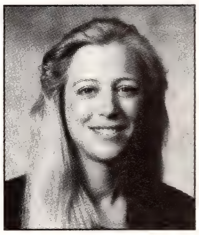
Language extensions and support for new features will enhance VHDL's usability and increase its acceptance. Formats for describing waveforms and testability structures broaden its usefulness into other aspects of electronic design.

Interest continues into how VHDL could describe timing and physical considerations. Standard math packages would provide common functions and predictability to designers. Several serious efforts are under way to create an analog VHDL that would bring the advantages of VHDL from the digital world.

Designers are building next-generation design technologies on VHDL. The emerging field of ESDA (electronic system design automation) will result in tools that allow developers to create designs graphically at a high level of abstraction. The ESDA tools will automatically produce VHDL, which logic-synthesis tools can, in turn, readily synthesize into a gate-level design.

The government's VHDL project has been largely successful, has penetrated into the commercial arena, and has changed the way that design engineers work. It's a prime example of dual-use technology that has quite effectively served both military and commercial needs. EDN

Author's biography



Karen Bartleson, manager of CAD at United Technologies Microelectronics Center (UTMC), Colorado Springs, CO, directs the engineering group responsible for producing UTMC's ASIC design system. She has been with the company for $6\frac{1}{2}$ years. Karen holds a bachelor of science in engineering degree from California State Polytechnic University, is a member of the IEEE, and enjoys fishing, PCs, and gourmet cooking.

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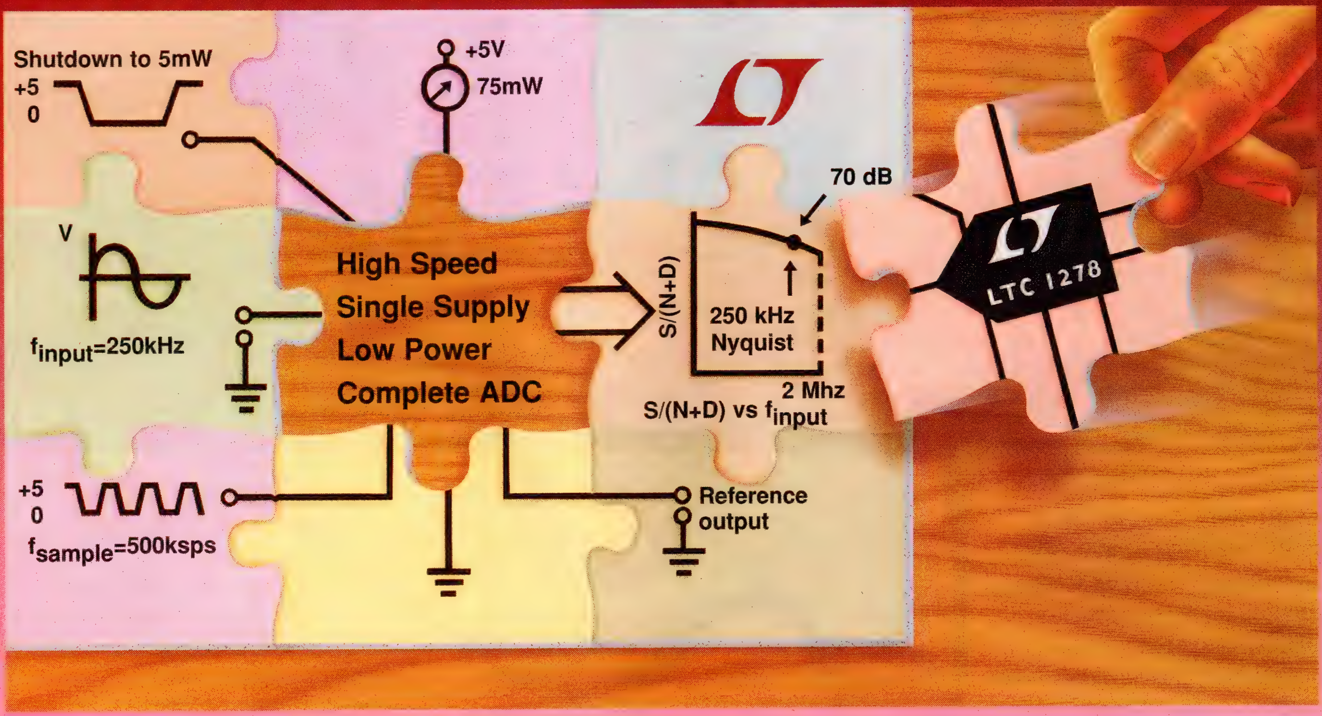

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EDITED BY CHARLES H SMALL & ANNE WATSON SWAGER

Oscillator lowers distortion and phase noise

GIOVANNI STOCHINO, ERICSSON TELECOMUNICAZIONI SPA, ROME, ITALY

In addition to its normal role of controlling oscillation frequency, the crystal in **Fig 1** also acts as a high-Q, self-tuned output filter, which rejects the noise and harmonics of its input voltage, V_B. The result is a clean output-frequency spectrum. With an output frequency of 10.7 MHz, second harmonic distortion is –76 dBc, and third-harmonic distortion is –72 dBc. Other harmonics are less than 80 dBc, and output power is +7 dBm at 50Ω. C_1 and R_4 counterbalance the undesirable effects of the parallel capacitance C_P of the crystal, which represents a side path through which the highest harmonics of V_B can reach the output.

The circuit is basically a Clapp oscillator except that a four-transistor voltage follower (Q_1 to Q_4) replaces the single common-collector transistor. Also, instead of grounding the crystal, this design connects it to a virtual ground, V_G. Therefore, the circuit forces the crystal current, I_X, to flow through R_5, thus producing the output voltage $V_{OUT}=-R_5I_X$. The series resonance of the crystal mostly determines the oscillation frequency according to

$$f_O \approx 1/(2\pi\sqrt{L_SC_S}).$$

Compared with the common single-transistor design, this modified Clapp oscillator has a more symmetrical and linear transconductance ($g(I_E)=I_E/V_B$) over a wide range of V_B. R_1, R_2, and R_3 help control the excess of the oscillator loop gain, and, hence, the amplitude and wave shape of crystal voltage V_B. With the values specified, the oscillator is stable under all operating conditions and produces a fairly sinusoidal waveform at node B.

For best performance, the impedance at node G must be low over a wide frequency range. Thus, the circuit uses a wideband current-feedback amplifier that has a built-in low open-loop impedance at its inverting input. R_5 further reduces the impedance at node G to fractions of an ohm over a wide frequency range. Due to the high Q of the crystal filter, the circuit also rejects all out-of-band noise produced by both the four-transistor voltage follower and IC_1, which results in low phase noise. (DI #1574) EDN

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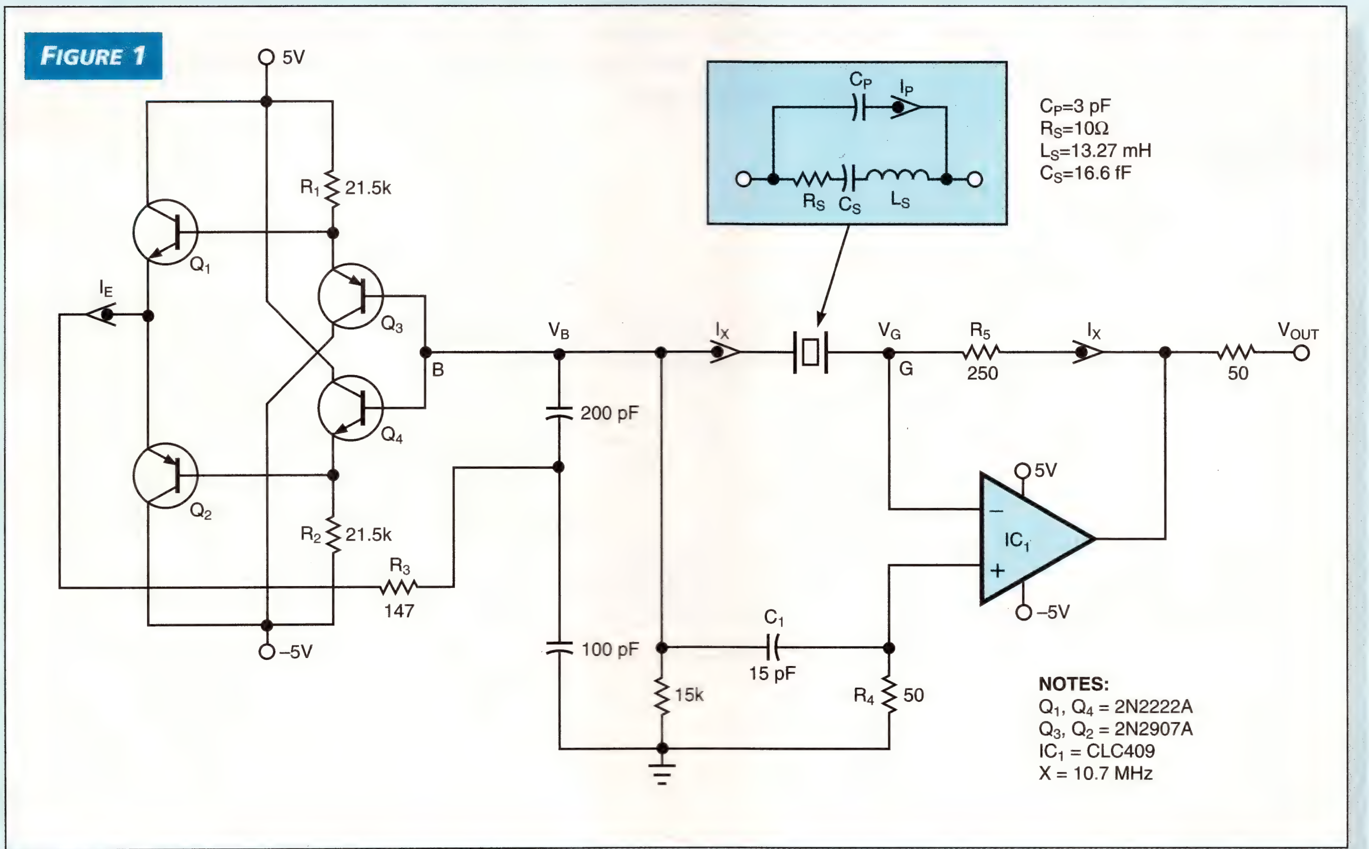
FIGURE 1



This low-distortion oscillator is essentially a modified Clapp oscillator that uses a four-transistor voltage follower instead of a single transistor and connects the crystal to a virtual ground at node G.

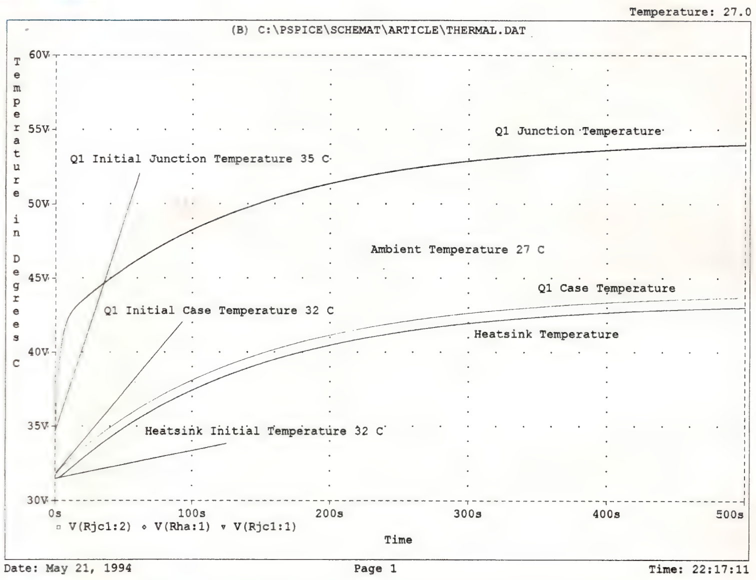
Spice runs thermal analysis

MICHAEL WYATT, HONEYWELL INC, CLEARWATER, FL

BBS Performing a thermal analysis in Spice allows you to study a circuit's electrical performance and the accompanying thermal effects simultaneously. For example, a Spice simulation that includes thermal analysis allows you to study the effects of reactive loads on amplifier dissipation or driver waveforms on power-supply switching-transistor dissipation and even secondary breakdown prediction. Spice maintains accurate results in temperature regions where the dominant method of heat transfer is by conduction and convection, where most electronic systems operate.

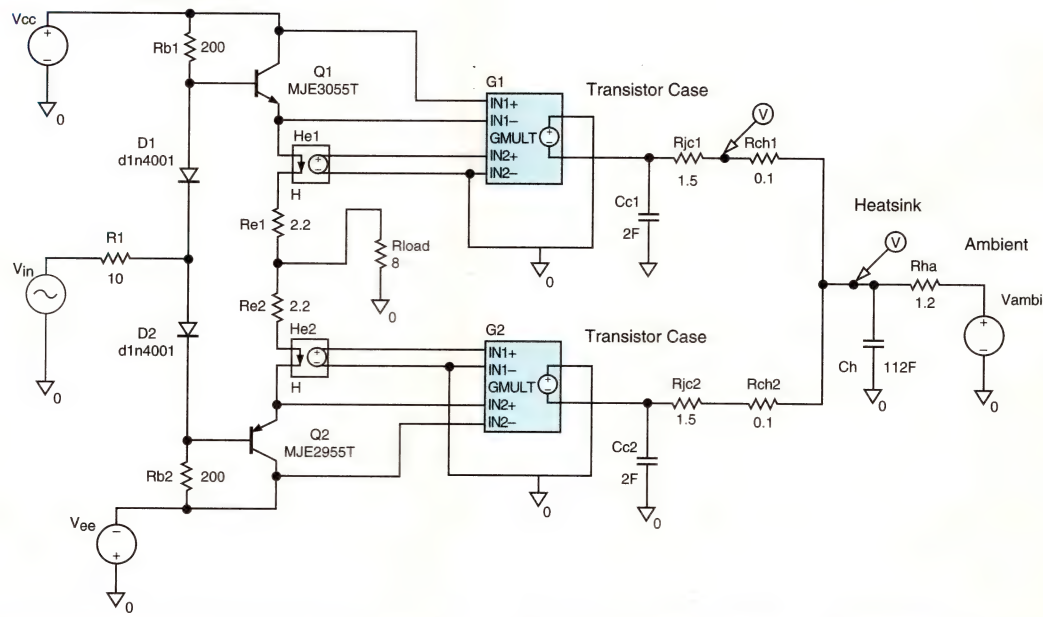
To perform a steady-state or transient thermal analysis in Spice requires a straightforward transformation of thermal elements to their electrical counterparts (**Table 1**). The circuit in **Fig 1**, implemented in PSpice (MicroSim Corp, Irvine, CA), provides an example of the concept. (A copy of the netlist is attached to **EDN BBS/DI_SIG #1576.**) Q1, Q2, D1, D2, and surrounding components comprise a typical class A/B power amplifier for audio and servo

FIGURE 2



This PSpice simulation illustrates the effect of the thermal capacity of the transistor case and the heat sink; the high-thermal-capacity heat sink requires considerable time to heat and limits the rate of temperature rise of the smaller thermal-capacity transistor case.

FIGURE 1



This PSpice schematic models the thermal effects of the transistor case, heat sink, and ambient temperature using electrical equivalents of the thermal quantities according to Table 1.

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applications. D1 and D2 establish a quiescent current in Q1 and Q2 to reduce the crossover distortion common to true class-B amplifiers. Vin and R1 model the driver stage, and emitter resistors Re1 and Re2 create local feedback to help stabilize the amplifier's dc operating point.

Current-controlled voltage sources He1 and He2 measure Q1's and Q2's emitter currents, respectively, and convert these currents into voltages. Voltage-to-current multipliers G1 and G2 multiply the instantaneous transistor collector-to-emitter voltage by the transistor emitter current. This product is a conservative estimate of the instantaneous power that each transistor dissipates.

The network that follows G1 and G2 models the thermal elements of the transistor cases and heat sink. Each multipliers' output is a current source that represents the instantaneous power generated within each transistor, where the scale factor is 1A=1W. Rjc is the thermal resistance between the transistor junction and the case expressed in degrees centrigrade (or kelvin) per watt. Rch is the thermal resistance between the transistor case and heat sink. Cc is the thermal capacity of the transistor case, and Ch is the thermal capacity of the heat sink expressed in watt-seconds per degree centigrade. Thermal capacity equals the product of the mass (in kilograms) and the material's specific heat (in watt-seconds per kilogram°C). Rha is the thermal resistance between the heat sink and ambient. Rhc has a lower value for forced-air cooling than for convection cooling. **Fig 1** models the ambient temperature using an ideal voltage source, Vambient, with a dc voltage equal to the ambient temperature. Vambient can be in kelvin or degrees centigrade.

Fig 2 illustrates the thermal effects of applying a sine-wave signal to the power amplifier in **Fig 1**. The heat sink and transistor case rise in temperature vs time. These curves illustrate the effect of the thermal capacity of the transistor case and the heat sink. The high-thermal-capacity heat sink required considerable time to heat and limits the rate of temperature rise of the smaller thermal-capacity transistor case. (DI #1576) EDN

TABLE 1—ELECTRICAL AND THERMAL EQUIVALENTS

Thermal equivalent	Units	Electrical equivalent	Units
Resistance	°C/watt	Resistance	Volts/amp
Power	Watts	Current	Amps
Temperature	°C or kelvin	Potential	Volts
Thermal capacity	Watts-seconds/°C	Capacitance	Coulombs/volt

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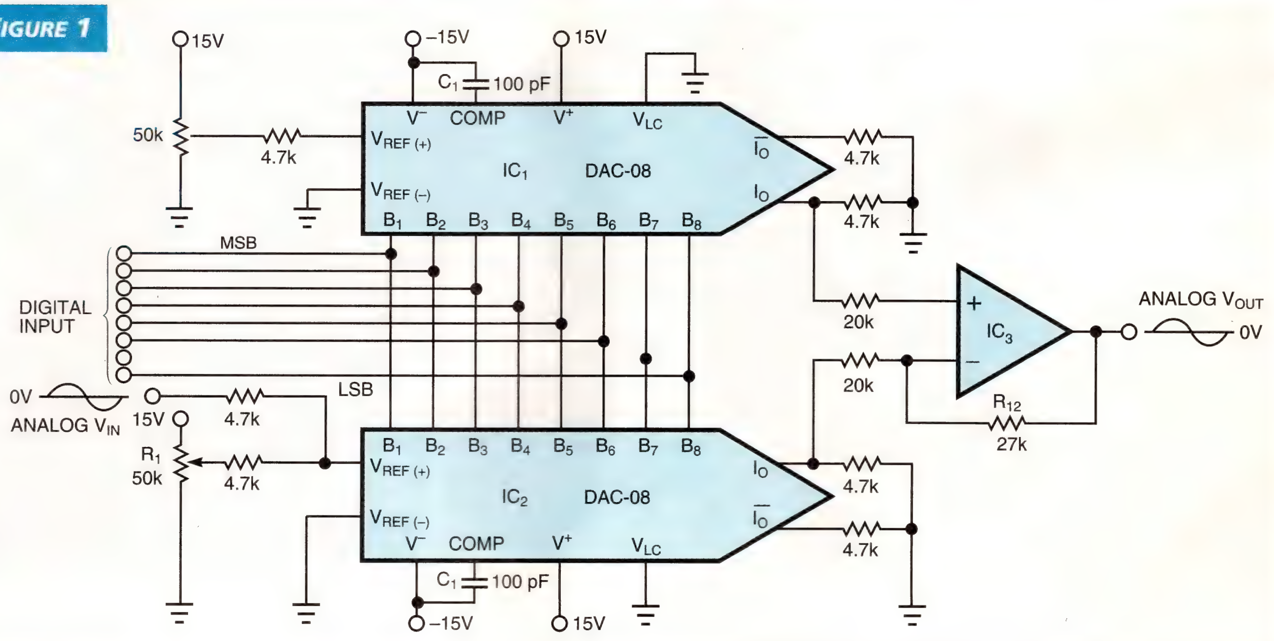
FIGURE 1



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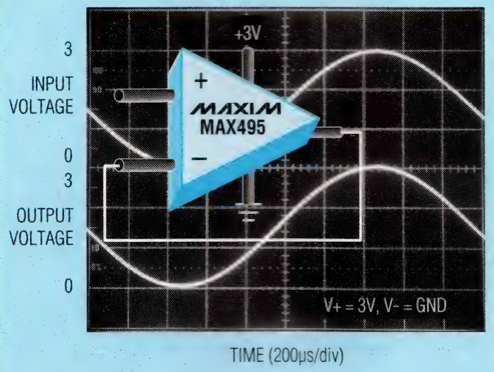

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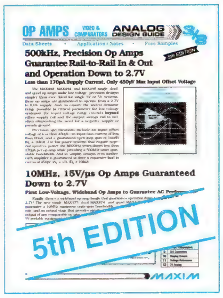

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CIRCLE NO. 107

plies this dc component, which then appears at the output. In attenuator applications for which the digital number acts as the attenuation-control word, the desired bipolar component in the output signal can be recovered through an output-decoupling capacitor. However, in amplitude-modulator applications where the multiplying number represents the digitized time samples of the modulating signal, this dc component, which now varies in accordance with the modulating waves, can pass through the capacitor.

The scheme in **Fig 1** overcomes this drawback and delivers a true bipolar output signal. IC_1 acts as a tracking DAC and IC_2 as the multiplying DAC. When the dc bias at the $V_{REF}(+)$ input of IC_1 is exactly equal to the quiescent bias of IC_2 at its $V_{REF}(+)$ input, the voltage output at IC_1's I_O and $\overline{I_O}$ pins precisely tracks in amplitude and phase the dc components at IC_2's I_O and $\overline{I_O}$ pins. Differential-amplifier IC_3 rejects these common-mode signals, leaving a true bipolar signal.

Any op amp with high CMRR, low dc offset, and gain-bandwidth product sufficient to handle the highest frequency components in the applied analog input signal at the desired gain is suitable for IC_3. Adjusting R_1 provides the necessary dc offset required by IC_2 during bipolar operation.

This circuit is much faster than any CMOS multiplying DAC. (DI #1575) EDN

To Vote For This Design, Circle No. 379

$10 receiver has microvolt sensitivity

CHARLES KITCHIN, ANALOG DEVICES INC, WILMINGTON, MA

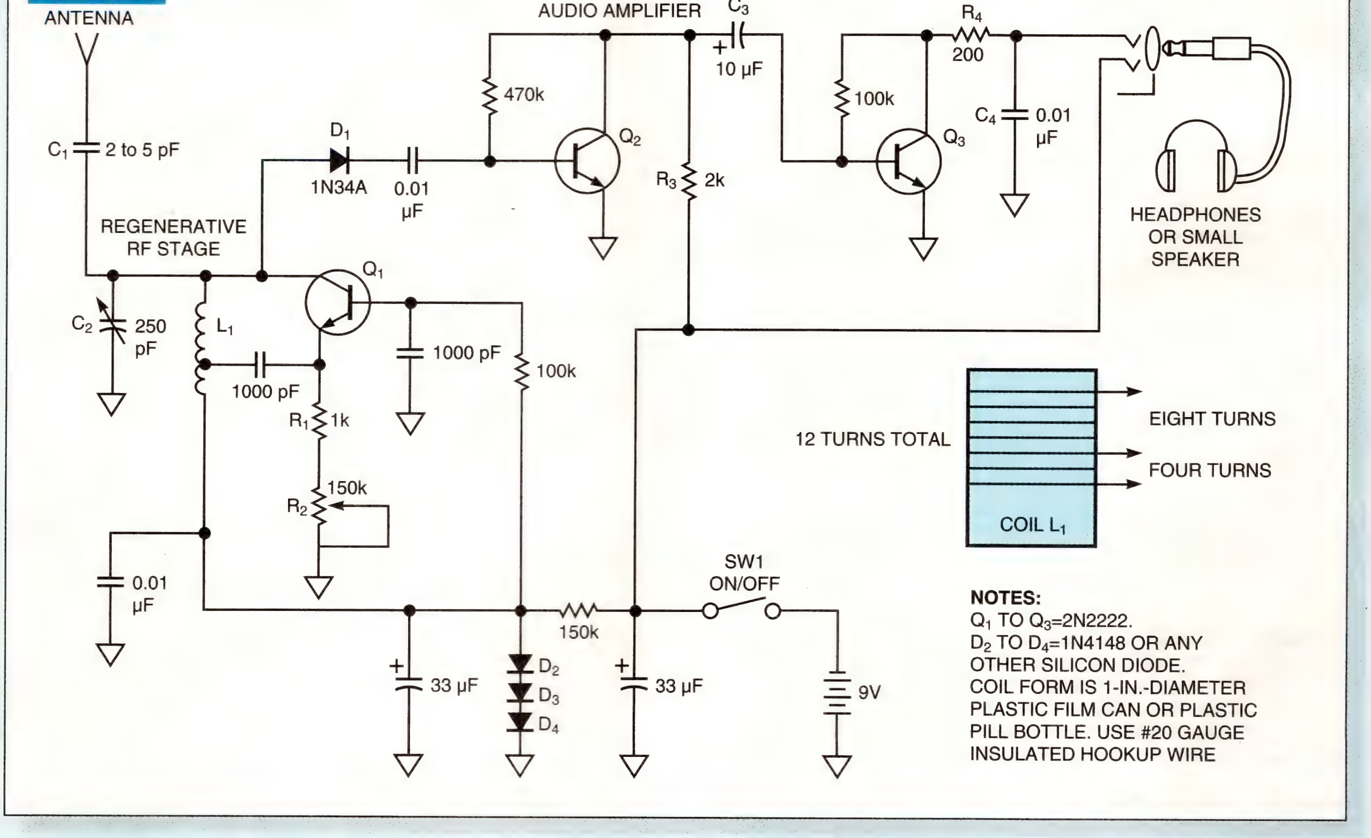
The three-transistor circuit in **Fig 1** costs less than $10 to build, uses commonly available components, and consumes less than 10 mA from a single 9V battery. If you wind coil L_1, as the **figure** shows, the circuit receives signals in the 5- to 15-MHz short-wave band. You can add turns to or subtract turns from L_1 (or change C_2) to receive other frequencies.

Q_1, a 10¢ bipolar transistor, acts as a high-gain regenerative stage and amplifies microvolt-level signals at the antenna up to hundreds of millivolts to drive diode-detector D_1. In addition to providing high gain, regeneration also greatly increases the Q (selectivity) of the circuit, producing a high-Q circuit, which can use low-cost coils (or free hand-wound coils).

Using a high-transconductance bipolar transistor for Q_1 rather than a vacuum tube or JFET provides much more gain per microamp of current. However, in previous bipolar circuits of this type, the regeneration level has been difficult to control. In this circuit, R_1 and R_2 provide a large amount of negative bias at the emitter of Q_1 to achieve smooth control.

Text continued on pg 102

FIGURE 1



NOTES:
Q_1 TO Q_3=2N2222.
D_2 TO D_4=1N4148 OR ANY OTHER SILICON DIODE.
COIL FORM IS 1-IN.-DIAMETER PLASTIC FILM CAN OR PLASTIC PILL BOTTLE. USE #20 GAUGE INSULATED HOOKUP WIRE

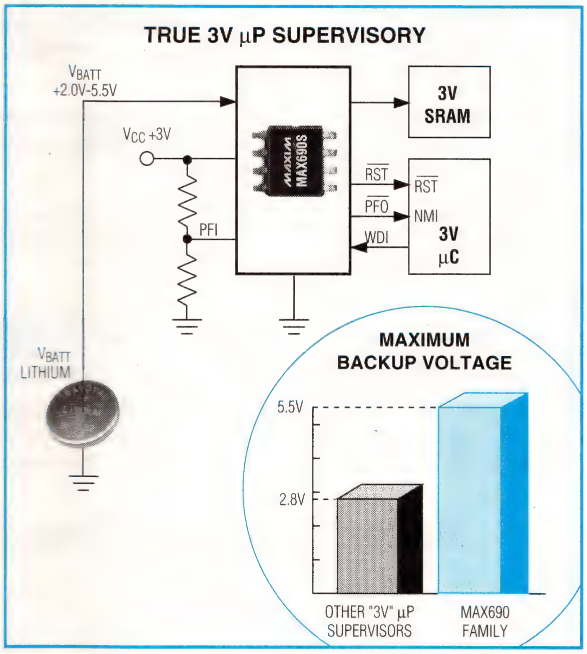
Winding L_1 allows this $10 circuit to receive µV-level signals in the 5- to 15-MHz short-wave band.

+3V µP SUPERVISORS SOLVE TOUGH BATTERY BACKUP PROBLEM

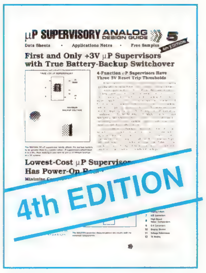
Backup Battery Voltage Can Be Greater Than A Valid +3V V_{CC} Without Causing False Switchovers

This family of 3V µP supervisors has been specifically designed for +3V systems. **These devices are not respecified +5V ICs.** They offer true battery-backup switchover, which is difficult to achieve at 3V. Choosing the higher of the backup battery or main supply—as 5V µP supervisors do—would lead to erroneous backup switchovers, since the backup battery is typically greater (3V to 3.6V) than the main power supply (2.7V to 3.6V) during normal operating conditions. The MAX690R/S/T, MAX704R/S/T*, and MAX804-MAX806R/S/T* avoid this problem by switching over to the backup battery only when the main supply has fallen below 2.4V.

- **RESET and $\overline{\text{RESET}}$ Outputs**
- **3 RESET Trip Thresholds:**
  3.0V-3.15V — "T" Suffix
  2.85V-3.00V — "S" Suffix
  2.55V-2.70V — "R" Suffix
- **Battery-Backup Switchover**
- **1.6 seconds Watchdog Timer**
- **40µA I_{SUPPLY} (Operating Mode)**
- **1µA I_{SUPPLY} (Backup Mode)**
- **Power-Fail Warning**
- **Manual-Reset Input**
- **Guaranteed $\overline{\text{RESET}}$ Assertion to V_{CC} = 1V**
- **8-pin DIP and SO Packages**



The MAX690 3V µP supervisor family allows the backup battery to be greater than V_{CC} (unlike other µP supervisors which limit it to 2.8V), thus making it possible to use a 3V lithium backup in a 3V system.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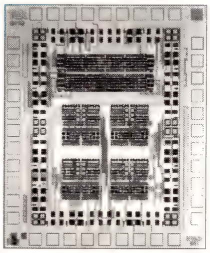
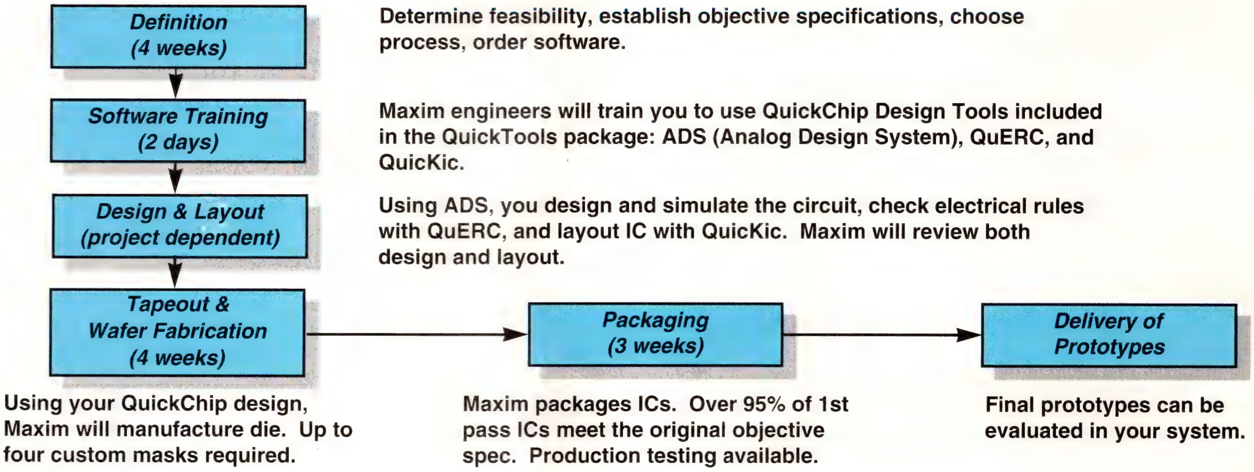


Maxim's QuickChip design automation approach consists of several "core" array families of high-speed bipolar transistors, capacitors, and resistors, optimally configured for interconnection. QuickChip arrays are easy to use, and since there are only a few masks to design, QuickChip is less expensive and less time consuming than the full custom approach. Once final designs are completed and approved, finished wafers can typically be delivered within 4 weeks.

This QuickChip 7 array on the GST-1 process has one digital (ECL) macro-tile and four analog macro-tiles for a total of: 592 NPNs, 56 PNPs, 64 Schottky diodes, 64 ESD diodes, 1,408 resistors, 48 MOS capacitors, and 40 pads.

QuickChip Project Flow


Definition (4 weeks)
Software Training (2 days)
Design & Layout (project dependent)
Tapeout & Wafer Fabrication (4 weeks)
Packaging (3 weeks)
Delivery of Prototypes

Determine feasibility, establish objective specifications, choose process, order software.

Maxim engineers will train you to use QuickChip Design Tools included in the QuickTools package: ADS (Analog Design System), QuERC, and QuicKic.

Using ADS, you design and simulate the circuit, check electrical rules with QuERC, and layout IC with QuicKic. Maxim will review both design and layout.

Using your QuickChip design, Maxim will manufacture die. Up to four custom masks required.

Maxim packages ICs. Over 95% of 1st pass ICs meet the original objective spec. Production testing available.

Final prototypes can be evaluated in your system.

World-Class Design Tools and Process Capabilities

Maxim's design tools shorten design time and help meet target specifications on the first pass.

QuickTools is a powerful software package that provides design engineers with complete IC, schematic, simulation, and layout capabilities. It includes:

- **ADS,** an integrated schematic capture, circuit simulation, results processing, and display environment.
- **QuERC,** a bias analysis electrical rules checker.
- **QuicKic,** a fast, error-free netlist-driven layout editor that checks process design rules, connectivity,and interconnect parasitics as the layout is being accomplished.

All processes are available for full custom work. C-Pi/SHPi and GST-1 have QuickChip arrays in various configurations to meet your requirements.

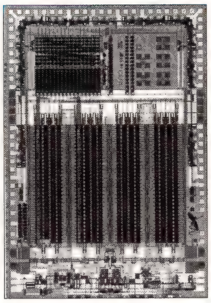
NAME	NPN BV_{CEO} (V)	NPN f_T (GHz)	PNP BV_{CEO} (V)	PNP f_T (GHz)	JFET	DIGITAL DENSITY (GATES)	ISOLATION	METAL LAYERS	THIN FILM RESISTORS	SCHOTTKY DIODE
SHPi	8	9	9	0.1	YES	3K	OXIDE	2	YES	YES
C-Pi	9.5	9	10.5	5.5	YES	3K	OXIDE	2	YES	YES
GST-1	5.5	13	—	0.1	NO	20K	TRENCH	3	YES	YES
GST-2	4.5	27	—	0.1	NO	60K	TRENCH	3	YES	YES

- **C-Pi** is a recessed-oxide-isolated high-speed complementary bipolar process optimized for analog signal acquisition, amplification, and sourcing. Without the vertical PNP option, C-Pi is designated as **SHPi**.
- **GST-1** is a high-speed self-aligned double-polysilicon bipolar process ideally suited for highly integrated, mixed analog, and digital ICs. **GST-2** offers the highest speed and device density, with 27GHz f_Ts and up to 60K gates/IC.

DESIGN SOLUTIONS UP TO 27GHz

STATE-OF-THE-ART DESIGN TOOLS AND PROCESS TECHNOLOGIES

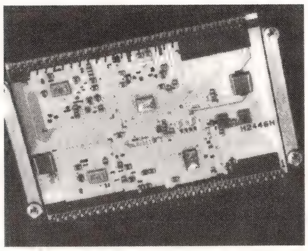
Maxim's Full Custom Approach



In addition to the QuickChip approach, Maxim also offers a high-frequency full custom capability. This method is ideal for high-volume products where optimized unit cost reduction and ultimate high frequency performance are key factors. Full custom offers complete flexibility in choosing individual devices and location. Your custom IC can be fully designed by either Maxim's experienced design staff or by your own skilled analog designers using Maxim's design tools.

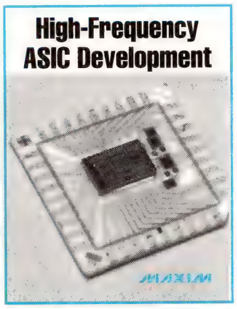
This 8-bit 500 Msamples/sec A/D converter is a full custom design. It has full flash topology and greater than 500MHz small signal bandwidth.

Hybrid and Module Development



Our high-frequency hybrid design and manufacturing group can develop your complete system. Using HCAD-III, an internally developed hybrid software design and layout system, multi-chip modules (MCMs) can be developed that will work right the first time. Process capabilities include: thick film, thin film, multilayer ceramic, MCM, chip and wire, mixed technologies, electro-optic, and electrical test and trim up to 60GHz. Examples of previously designed hybrids include 350MHz video display drivers and ATE pin drivers for 100MHz test systems. Our high-frequency packaging and assembly expertise is second to none! Let Maxim help you with high-frequency problems.

This multichip module uses two full custom Maxim ICs and two custom CMOS ICs. It represents a complete 200MHz analog oscilloscope on a board.



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R_2 allows for user control of the regeneration. You should adjust the pot so that Q_1 is just at the threshold of oscillation where both gain and selectivity are maximum.

Q_2 and Q_3, a two-transistor amplifier, which has sufficient output level to directly drive headphones or a small speaker, amplify the detected audio signal output from D_1. R_3 can become a volume control if you replace it with a 2-kΩ potentiometer and connect C_3 to its wiper. R_4 and C_4 form a low-pass filter that maintains circuit stability and improves the receiver's sound quality. D_2, D_3, and D_4 implement a low-cost voltage regulator to keep the voltage supplying Q_1 fairly constant, which minimizes drift.

This receiver works with a short whip antenna, which you can connect directly to the top of tuning-capacitor C_2, or you can use an outside antenna for better reception. When you use an external antenna, C_1 must decouple the antenna's capacitance from L_1. The regenerative stage of Q_1 operates at less than 30 μW (50 μA at 0.6V). This low power, combined with the use of a small capacitor for C_1, prevents the detector (if it oscillates) from interfering with other receivers in the area. This problem was common in the 1920s and 1930s when tube-type regenerative receivers of this type, dissipating several watts of power, caused interference. (DI #1572) EDN

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EDN SOFTWARE SHORTS

Digital-image-manipulation programs are easy to use

VLADIMIR BOCHEV
INSTITUTE OF INFORMATICS, SOFIA, BULGARIA

The suite of programs, including source code, attached to **EDN BBS/DI_SIG #1567** allows you to perform elementary rotations, translations, and transformations on raw gray-level images that are 256×256 pixels in size.

To Vote For This Design, Circle No. 381

DOS prompt signals exit to shell

MN JAYARAM
BARC, TROMBAY, BOMBAY, INDIA

The C source program attached to **EDN BBS/DI_SIG #1568** will, when compiled, change your DOS prompt to read "EXIT>" when you shell out of a program to DOS.

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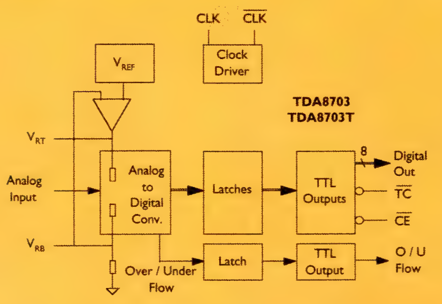
TDA8709A	TTL	30	8	7.5@4.43	380	3:1 Mux, VGA, Clamp
TDA8758	TTL	30	8	7.2@4.43	485	Mux, AGC, Dual ADC, 16 Bit YC
TDA8755	TTL	20	8	7.1@4.43	550	Clamps, Dual ADC, YUV 4:1:1
TDA8706	TTL	20	6	5.7@4.43	300	3 Clamps, 3:1 Mux
High-Speed A-to-D Converters						
TDA8718	ECL	600	8	7.5@4.43	990	Low Cin 0 & U Flow
TDA8716	ECL	120	8	7.7@4.43	780	Low Cin 0/U Flow
TDA8714/7 TDA8714/6 TDA8714/4	TTL	75 60 40	8	7.7@4.43	340	0/U Flow
TDF8704/5 TDF8704/4 TDF8704/2	TTL	50 40 20	8	7.5@4.43	380	-40/+85°C Temp, Internal Ref.
TDA8760/5 TDA8760/4 TDA8760/2	TTL	50 40 20	10	8.8@4.43	850	S/H, 0/U Flow
TDA8703	TTL	40	8	7.1@4.43	290	Internal Ref., 0/U Flow

TDA8703 8 Bit High Speed A/D



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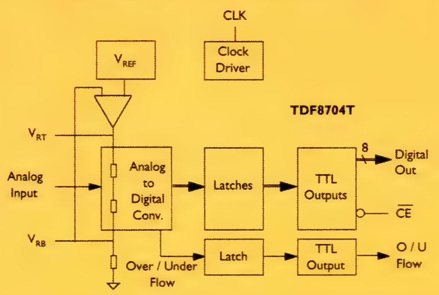
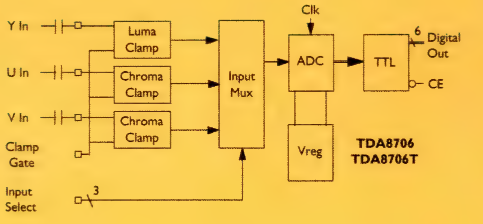
- 14 pF input capacitance
- Binary or two's complement output
- TTL I/0 and 3 state outputs
- Overflow/underflow 3 state output
- +5 V supply. 290 mW power dissipation
- 24 pin DIP or SO

TDF8704 High Speed & Temperature A/D



- 8 bit A/D
- 50 MHz minimum sample rate
- -40°C to +85°C operating temperature
- Internal voltage reference
- 7.5 effective bits @ 4.43 MHz input
- 14 pF input capacitance
- Binary output
- TTL I/O and 3 state outputs
- Overflow/underflow 3 state output
- +5V supply. 380 mW power dissipation
- 24 pin SO

TDA8706 6 Bit A/D with Mux



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- Two chrominance '128' clamps
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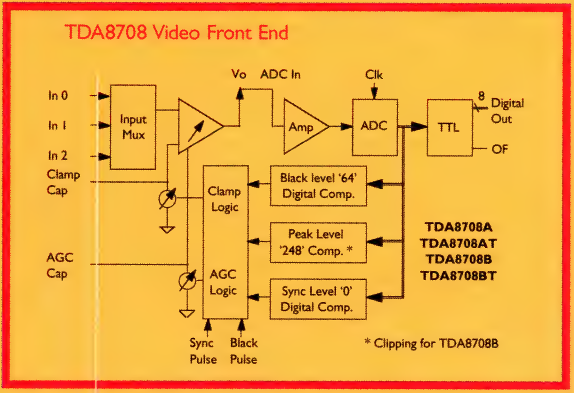
TDA8708 Video Front End

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- Front-end A/D
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- Black level clamp
- Sync amplitude AGC
- 30 MHz minimum sample rate
- 1 pF input capacitance
- 7.5 effective bits @ 4.43 MHz
- +5 V supply. 365 mW power dissipation
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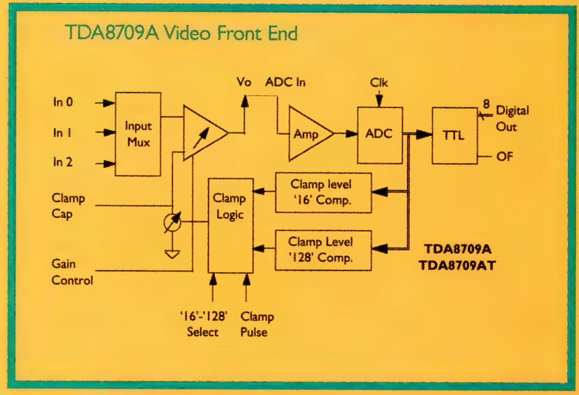
TDA8709A Video Front End

- 8 bit folding/interpolating A/D
- Front-end A/D
  - PAL, NTSC, SECAM, Y-C
- 3 input Video MUX
- Back porch clamp '16' or '128'
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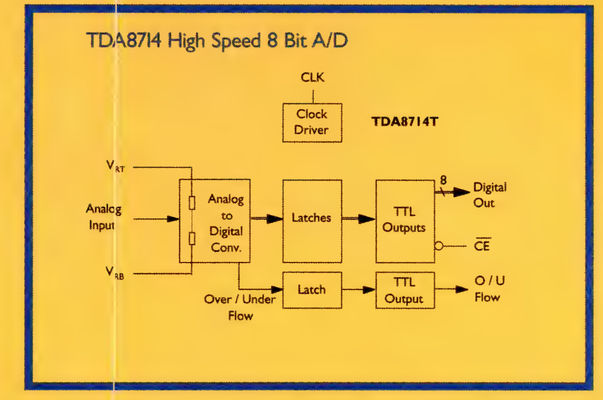
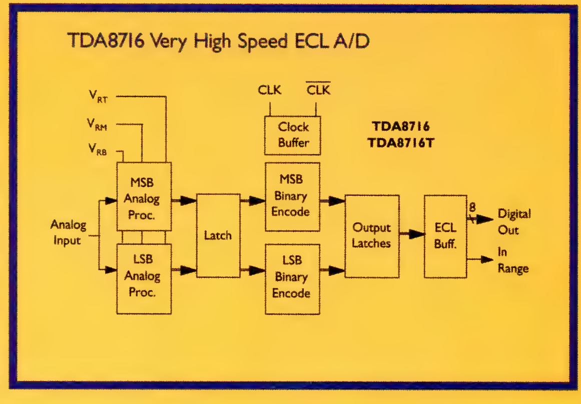
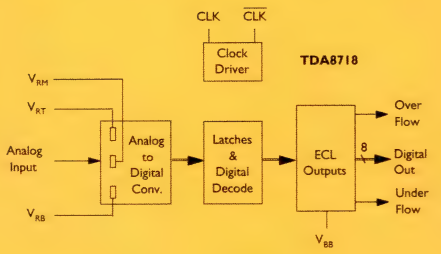

TDA8714 High Speed 8 Bit A/D

- 8 bit A/D
- 75 MHz minimum sample rate
- 7.7 effective bits @ 4.43 MHz input
- 14 pF input capacitance
- Binary output
- TTL I/0 and 3 state outputs
- Overflow/underflow 3 state output
- +5 V supply. 340 mW power dissipation
- 24 pin SO or SSOP


TDA8716 Very High Speed ECL A/D

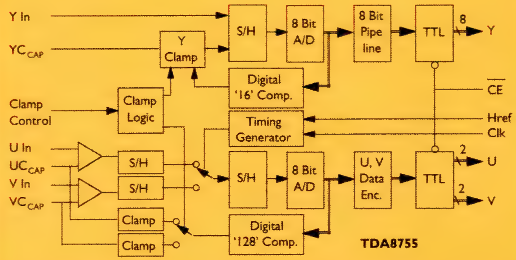
- 8 bit A/D
- 120 MHz minimum sample rate
- 7.7 effective bits @ 4.43 MHz input
- 13 pF input capacitance
- Binary or two's complement output
- ECL (10KH family) I/O
- Differential clock
- Overflow/underflow ECL output
- -5.2 V supply. 780 mW power dissipation
- 24 pin DIP or 32 pin SO

TDA8718 Ultra High Speed ECL A/D



- 8 bit A/D
- 7.5 effective bits @ 4.43 MHz input
- 600 MHz minimum sample rate
- 3.5 pF input capacitance
- Binary output
- ECL (100K family) I/O
- Differential clock
- Overflow and underflow ECL output
- 50Ω load drive capability
- -4.5 V supply. 990 mW power dissipation
- 28 pin PLCC

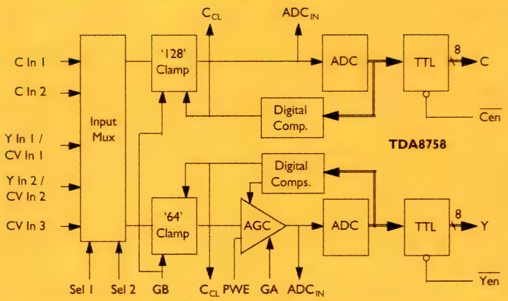
TDA8755 YUV A/D Interface



	U, V- Chroma	Y- Luma
Inputs	2:1	1
Clamp Level	'128'	'16'
Output	Two's Comp.	Binary
Differential Linearity	±0.5 LSB	±0.5 LSB
Sampling Rate (min)	20 MHz	20 MHz
Input Capacitance	1 pF	1 pF

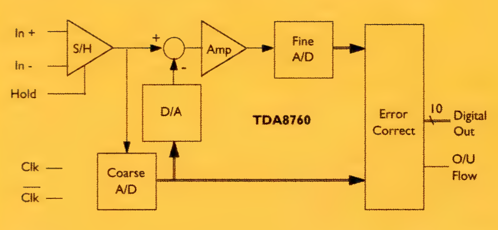
Effective Bits @ 4.43 MHz	7.1
Crosstalk	-55 dB
Output Format	4:1:1
TTL I/O	Yes
Power Supply/Dissipation	+5 V / 550 mW
32 pin SO Package	

TDA8758 S Video Dual ADC



	C- Chroma	Y- Luma
Inputs	2:1	2:1 or 3:1 CV
Clamp Level		'128'
AGC (Sync = 64 LSBs)	'64'	
Peak White ≤ '255'	–	Yes
Amp Gain Range	–	Yes
Analog Bandwidth	–	-3 dB/+3 dB
Sampling Rate (min)	45 MHz	45 MHz
Effective Bits @ 4.43 MHz	30 MHz	30 MHz
	7.2	7.2
Crosstalk		
TTL I/O	-50 dB	
Power Supply/Dissipation	Yes	
48 pin TQFP Package	+5 V / 485 mW	

TDA8760 10 Bit ADC



- 10 bit A/D
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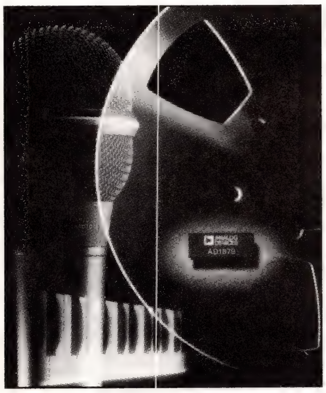
Low-power token-ring controller meets PCMCIA needs. Using less than 170 mA, a two-chip token-ring chip set provides a controller and a media driver. The TC35813F controller uses control registers and interrupt logic to interact with the host CPU and provides command-processing and ring functions. The TB320-44F media interface provides an encoder/ decoder, clock extraction, driver circuits, and line-error detection at 4 or 16 Mbps. Both devices meet PCMCIA height requirements, and the set costs $75 (1000). **Toshiba America Electronic Components Inc**, Irvine, CA. (714) 455-2000.
Circle No. 312



Digital-audio ADCs have differential inputs. The 16-bit AD1878 and 18-bit AD1879 sample input signals at 3.072 MHz, 64 times the output-word rate of 48 kHz, all based on a master clock of 12.288 MHz. Each input channel is fully differential, and an internal voltage reference provides a stable source over temperature and time to both channels. Each ADC time-multiplexes output data from each channel to a flexible serial interface. Typical performance specifications include 103-dB S/N ratio, –98-dB THD plus noise, 0.001-dB passband ripple, and 115-dB stopband attenuation. The 28-pin DIPs operate from ±5V, and respective prices are $38 and $42 (1000). **Analog Devices Inc**, Wilmington, MA. (617) 937-1428.
Circle No. 313

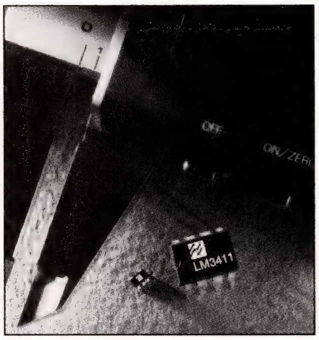
Single-supply op amps have 3-MHz gain-bandwidth product. The dual OP291 and quad OP491 feature rail-to-rail operation on both inputs and outputs along with low power consumption, high accuracy, and wide bandwidth for a single-supply device. The power supply voltage ranges from 3 to 12V; the op amps also operate on ±5V supplies. Maximum supply current/ amplifier is 350 μA at 3V. Output voltages are within 50 mV of the positive and 10 mV of the negative supply, and sink and source current is 13 mA. Maximum voltage offset is 0.7 mV (80 μV typ) with 1.1 μV/°C offset drift. Maximum input-bias current is 50 nA. Slew rate is 400 V/msec, and settling time to within 0.01% of full scale is 22 μsec. The op amps' proprietary input stage allows the input voltage to exceed either supply by 10V without output-phase inversion or latch-up. In 8-pin DIPs and SOICs, the OP291 costs $2.16 and $2.20 (1000), respectively. In 14-pin packages, the OP491 costs $3.23 and $3.28, respectively. **Analog Devices**, Wilmington, MA. (617) 937-1428.
Circle No. 314

Digital telephone-answering device competes with tape-answering machines. The DTAD two-chip set employs a TMS320C25 DSP core to develop a digital telephone-answering device. The DTAD comprises the MSP58C80 mixed-signal processor and the MSP58C20 audio-band converter. The addition of 4 Mbits of audio RAM provides more than 15 minutes of recording time. The MSP58C80 contains 20k×16-bit words of ROM and 1312×16-bit words of RAM and delivers 16.3 MIPS. The MSP58C20 audio-band converter is the analog portion of a sigma-delta A/D converter. A vocoder algorithm stores data at 4.8 kbps. $14 for the two-device chip set (50,000). **Texas Instruments Inc**, Denver, CO (800) 477-8924. **Circle No. 315**

LCD controller operates at 2.7V. The KS0071 single-chip LCD controller provides the extra margin to drive a two-line, 24-character display reliably as low as 2.7V and as high as 5.5V. The device contains a character generator with display ROM containing 240 fixed characters and display RAM for custom fonts. The chip provides 32 common and 60 segment signal outputs, and an on-chip voltage doubler eliminates the need for a separate LCD supply voltage. The chip comes in a 128-pin QFP or as a bare die. Samples will be available in the third quarter at $2.80 (10,000). **Samsung Semiconductor Inc**, San Jose, CA. (408) 954-7274. **Circle No. 316**

16-Mbit DRAMs come in 300-mil packages. The KM44C4100A 4M×4-bit and the KMKM41C16000A 16M×1-bit DRAMs employ 0.45-μm technology and come in JEDEC-standard 300-mil TSOP and SOJ packages. The DRAMs employ lead-on-chip (LOC) packaging to achieve the package size. LOC places the bond pads in parallel rows down—instead of around—the center of the chip. The chip is then wire-bonded to a balanced-capacitance lead frame that extends over the top of the chip. The construction reduces voltage drops, inductance, and electrical noise compared with that of conventional plastic SOJ packages. $59 (1000). **Samsung Semiconductor Inc**, San Jose, CA. (408) 954-7000.
Circle No. 317

Down-converters operate at 3V. The UPC2758T high-IP_3 device suits PCN and wireless LANs. For low-current requirements, the UPC2757T draws 5.6 mA and provides 13 dB of gain at 2 GHz. The UPC2756T combines an oscillator, an IF amplifier, and a down-converter. Both the UPC2758T and UPC2757T feature a power-down function, which cuts bias current to near zero when the enable voltage drops below a given threshold. The UPC2757T costs $0.99 (100,000). **California Eastern Laboratories**, Santa Clara, CA. (408) 988-3500. **Circle No. 318**



Precision secondary regulator/driver controls isolated switcher's output voltage. The LM3411 integrates the precision reference, error amplifier, and optocoupler driver on the secondary side of an optical-feedback power supply. The device's trimmed 3.3 and 5V voltages eliminate the need for external pots and precision resistors. A SOT23-5 package occupies 6% of the space of comparable devices in an 8-pin DIP package, according to the vendor. The A grade has a guaranteed ±0.5% voltage specification, and the standard grade has a guaranteed ±1% precision. Output current ranges from 20 μA to 15 mA. The prices of the A and standard grade in SOT23-5 packages are $0.93 and $0.73, respectively. 8-pin DIPs are also available. **National Semiconductor**, Santa Clara, CA. (408) 721-6937.
Circle No. 319

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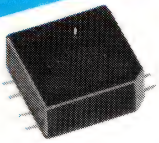

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CIRCLE NO. 95

ROM chip protects against viruses. The ChipAwayVirus ROM chip provides antivirus protection for NE2000-compatible LAN cards. The chip offers the Jumploading safety feature, which allows it to gain control of a computer system early in the boot process before DOS takes over. The device checks floppy disks for viruses during disk accesses, such as directory commands. It comes with a terminate-and-stay-resident integrity check, a virus-cleaning program, and disk-rescue utilities. $39. **Trend Micro Devices Inc**, Torrance, CA. (310) 782-8190. **Circle No. 320**

Delta-sigma modulator has 120-dB range. The 24-bit CS5321 implements a fourth-order, 256-times oversampling delta-sigma modulator with a dynamic range of 123 dB. The device's distortion performance of 118 dB at 256-times oversampling is a 10-dB improvement over other designs, the vendor claims. The device's switched-capacitor architecture minimizes the effects of clock jitter. In a typical application, the CS5321 modulator provides an oversampled serial bit stream at 256 kbps to the company's CS5322 decimation filter, which decimates the output to any of seven selectable update periods from 16 to 0.25 msec. Power dissipation of the modulator and decimation filter is 70 mW/channel. In 28-pin PLCCs, the CS5321/CS5322 chip set costs $175. **Crystal Semiconductor**, Austin, TX. (512) 442-7555. **Circle No. 321**

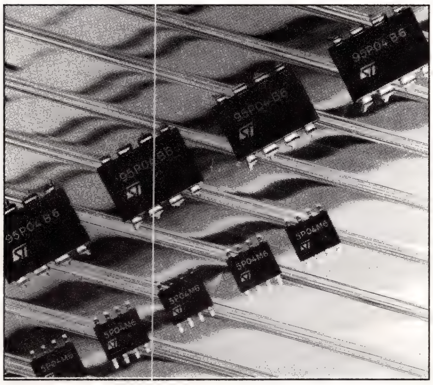
Dual-output linear regulator draws 70 μA in sleep mode. The CS-8147 has a logic-enable function that controls both of its output voltages; a logic high on this pin puts the regulator into sleep mode. The IC provides two regulated output-voltage levels: a primary output of 10V ±2.5% with a 500-mA capability and a secondary output of 5V ±5% with a 70-mA capability. Fault-protection features include reverse battery, 60V load dump, –50V reverse transient, short-circuit and thermal-runaway protection. The 5V output is inherently stable and doesn't require a compensation capacitor. In a 5-lead TO-220 package, the IC costs $1.18 (10,000). **Cherry Semiconductor Corp**, East Greenwich, RI. (800) 272-8140. **Circle No. 322**

Servo controller and power driver increase storage capacity by 60%. The highly integrated CL-SH7240 motion controller and CL-SH7205 power driver generate signals for positioning the heads and controlling the spin of the platters of a hard-disk drive. Using these ICs, you can implement a servo system in as few as five devices (the two ICs plus three passive components). The ICs also contribute to storage capacity increases of up to 60% by supporting complex head-positioning algorithms. In 100-pin, very-thin-profile QFPs, the two ICs cost $25 and $12.50 (1000), respectively. **Cirrus Logic Inc**, Fremont, CA. (510) 226-2001 **Circle No. 323**

16-bit industrial DAC costs $5.83. The serial-input DAC56 contains a stable, low-noise zener voltage reference, high-speed current switches, a resistor ladder network, and a low-noise output op amp. The DAC's high-speed interface can clock in data at 10 MHz. The IC first clocks MSB data into a 16-bit register and then latches it into a 16-bit parallel register. Key specifications include 0.012% max linearity error, guaranteed 12-bit monotonicity, voltage-out settling time of 1.5 μsec, voltage output of ±3V, and a current output of ±1 mA. The 16-pin DIP or SOIC operates with power-supply voltages from ±5 to ±12V. **Burr-Brown Corp**, Tucson, AZ. (800) 548-6132. **Circle No. 324**

Read-channel IC is programmable. The 32P4752 read-channel IC includes a pulse detector, four-burst servo capture, a programmable active filter, a timebase generator, and a data separator with a 1,7 RLL encoder/decoder. You can program the IC's data rates up to 64 Mbps using an external DAC whose reference current is set by a single external resistor. The device fully supports zoned recording and features improved group-delay equalization through a system of asymmetric zeros. Typical power dissipation is 500 mW at 5V. The IC draws less than 0.5 mA in sleep mode. $15 (10,000). **Silicon Systems**, Tustin, CA. (800) 624-8999, ext 151. **Circle No. 325**

Clock buffers guarantee low skew. The QS528xx and QS58xx clock-buffer families provide guaranteed part-to-part skew ratings <1.5 nsec. The 5805 and 5806 are TTL inverting and noninverting buffers with two banks of five-output lines. The 52805 and 52806 are similar and have noise-reduction series terminators. The 5244 is a 74FCT244 look-alike with pin-to-pin skew guaranteed to be <500 nsec. The parts are available in SOIC and QSOP packages, and prices start at $7.38 for the 528xx and 58xx series and $2.22 for the 5244. **Quality Semiconductor Inc**, Santa Clara, CA. (408) 450- 8000.
Circle No. 326



Serial EEPROMs are compatible with the SPI bus. The ST95P02C, ST95P04C, and ST95P08C serial EEPROMs are organized as 256×8, 512×8, and 1024×8 bits, respectively. The memories are organized as 16, 32, or 64 16-byte pages. They can write as much as 16 bytes in a nonvolatile cycle. Programming is self-timed with a maximum cycle time of 5 msec. A write-protect pin protects against spurious write operations. The Serial Peripheral Interface (SPI) protocol defines a three-wire bus, which the devices support at rates as fast as 1 MHz. $1.45 (1000). **SGS Thompson Microelectronics**, Lincoln, MA. (617) 259-2534. **Circle No. 327**

1-Mbit EPROM has 25-nsec access time. The CY27H010 is a 1-Mbit EPROM having a 25- to 70-nsec access time. The EPROM employs 0.65-μm technology and dissipates 660 mW during operation and <85 mW when it is deselected. Low programming current permits gang programming, and the device requires 12.75V for programming. It is available in a windowed or nonwindowed, 32-pin plastic DIP, 32-bit hermetic LCC, 32-pin PLCC, and 32-pin TSOP-I package. A 25-nsec version in a 32-pin PLCC costs $30.10 (100). **Cypress Semiconductor Corp**, San Jose, CA. (408) 943-2600.
Circle No. 328

Transceiver IC handles twisted-pair variations. The LXT300Z provides constant 3V driver impedance during the transmission of both marks and spaces and includes a driver performance monitor to handle the diverse impedances of twisted-pair telephone networks. The device operates at T1 (1.544 MHz) or E1 (2.048 MHz) data rates with transmit equalization good to 655 ft. It is compatible with a variety of PCM framers. The price is $13.80 (1000). **Level One Communications Inc**, Sacramento, CA. (916) 855-5000.
Circle No. 329

LCD controller extends battery life. By operating with voltages as low as 2.7V, the KS0071 LCD controller extends the usable life of batteries in handheld systems. The device drives a two-line, 24-character display. It contains a character generator with ROM holding 240 characters and RAM for custom fonts. It also offers a voltage doubler, eliminating the need for a separate LCD supply voltage. The device costs $2.80 (10,000) and will be sampling in the third quarter. **Samsung Semiconductor**, San Jose, CA. (408) 954-7000. **Circle No. 330**

Keyboard encoder provides power management. By going inactive between keystrokes, the UR5HCFJL keyboard encoder reduces its average power consumption to a few microamps. The device uses only 2 mA when processing a keystroke and conserves power by gradually dimming keyboard LEDs during long periods of inactivity. The encoder is PS/2-compatible and is available in 3, 3.3, and 5V operating ranges in a variety of package styles. Prices begin at $3.45, and a $140 evaluation kit is available. **USAR Systems**, New York, NY. (212) 226-2042.
Circle No. 331

PCI-SCSI controller enhances memory interfaces . The NCR53C815 PCI-based SCSI controller IC provides a variety of memory interfaces. It includes local PROM, burst op-code fetches, and flash-memory programming circuits. The device also handles big- and little-endian byte ordering on its 32-bit bus interface. It operates as a PCI bus master and provides synchronous SCSI

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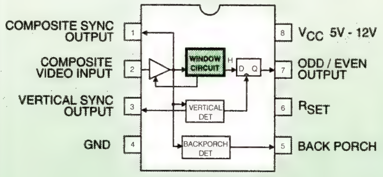

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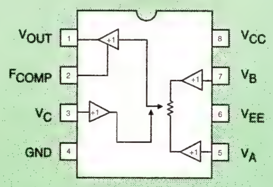

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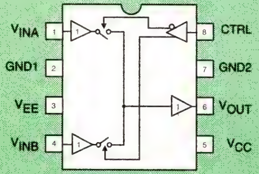

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CIRCLE NO. 65

transfers as fast as 10 Mbytes/sec. The price is $31.20 (5000). **NCR Microelectronics**, Colorado Springs, CO. (800) 334- 5454. **Circle No. 332**

16-Mbit DRAM has 1M×18-bit organization. The TC5118180AJ 16-Mbit DRAM has a 1M×18-bit organization, operates from 5V, and comes in a 400-mil-wide, 42-pin SOJ package. Access times are 60 or 70 nsec. The device employs 0.55-µm technology. **Toshiba America Electronic Components Inc**, Irvine, CA. (714) 455-2000. **Circle No. 333**

Dual UART is a second source to NS16C552. The ST16C2552 is a dual receiver and transmitter that serves as a second source to National Semiconductor's NS16C552. The UART transmits data from 50 Hz to 448 kHz. On-chip independent programmable-rate generators regulate transmit and receive modes. An internal loop-back feature provides on-chip diagnostic testing. The UART also comes with a FIFO buffer. Dual UART with FIFO in a 44-PLCC package, $7 (1000). **Startech**, Sunnyvale, CA (408) 745-0801. **Circle No. 334**

JFET-input op amp optimized for capacitive loads. The LT1457 dual op amp handles at least 10,000-pF loads without oscillating. Precision specifications include low maximum input-offset voltages of 450 µV in a plastic DIP and 1200 µV in an SO-8 package, input-bias current of 50 pA over the 0 to 70°C temperature range, and voltage noise of 13 nV/$\sqrt{\text{Hz}}$. Slew rate is 4V/µsec, and offset drift is 4 µV/°C. Prices of the 8-pin DIP and SOIC are $2.32 and $2.46 (1000), respectively. **Linear Technology Corp, Milpitas**, CA. (408) 432-1900. **Circle No.335**

Peripheral controller allows PC plug-and-play. Matching the IEEE-1284 specification for bidirectional parallel interface, the CL-CD1283 controller negotiates with the attached peripheral to establish a data link. The device provides a full implementation of the Extended Capabilities Port (ECP) for the ISA architecture and includes run-length-encoded (RLE) compression. It offers a 2-Mbyte/sec data-transfer rate, a 64-byte FIFO buffer, and a DMA channel. A 100-pin PQFP costs $7 (1000). **Cirrus Logic**, Fremont, CA. (510) 623-8300. **Circle No. 370**

SHORTS

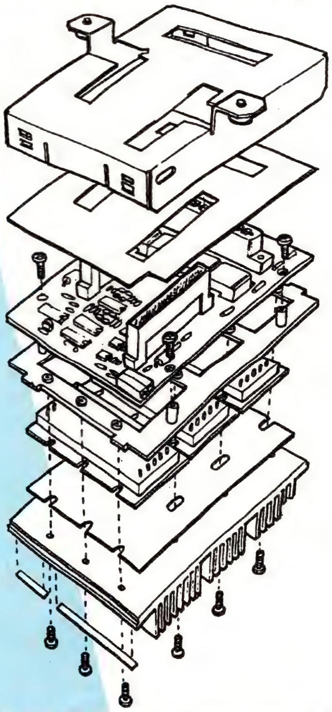
The EZ1086/85/84/83 family of low-dropout regulators, pin-compatible with Linear Technology's LT1086 family, are optimized for µP circuits running at <5V from a 5V supply. Guaranteed maximum dropout is 1.3V. $1.54 to $7 (100). **Semtech Corp**, (805) 498-2111. **Circle No. 371**

SGS-Thomson has expanded its range of standard linear ICs with a family of CMOS op amps, comparators, and timers for 3V operation. The TS3Vxx family includes dual rail-to-rail op amps, dual/quad micropower comparators, and single/dual timers. The devices operate with supply voltages from 2.7 to 16V and are specified at both 3 and 5V. **SGS-Thomson Microelectronics**, (617) 259-0300. **Circle No. 372**

The T0-263 power surface-mount package comes in three-, five-, and seven-lead versions and is a higher power alternative to the 24-lead wide-body SO. The company will initially offer its Simple Switcher power converters and low-dropout regulators in the package. Eventually, all power-management products will be available in both TO-263 and 220 packages. **National Semiconductor**, (408) 721-7509. **Circle No. 373**

To hasten acceptance of silicon ICs among wireless-system suppliers, Harris Semiconductor has cut prices of its growing line of seven wireless ICs for RF-IF conversion in receivers and transmitters. Prices cuts of up to 35% apply to the company's HFA3600 mixer and the HFA3101 Gilbert Cell transistor array, which now cost $2.07 and $1.94, respectively. **Harris Semiconductor**, (800) 442-7747 ext 7249. **Circle No. 374**

Three direct-pin replacements for the industry-standard DG400-series CMOS analog switches, the DG401, 403 and 405, are available through stock. The three come in 16-pin DIPs and SOICs for $1.84 to $4.25 (100). **Harris Semiconductor**, (800) 442-7747, ext 7226. **Circle No. 375**



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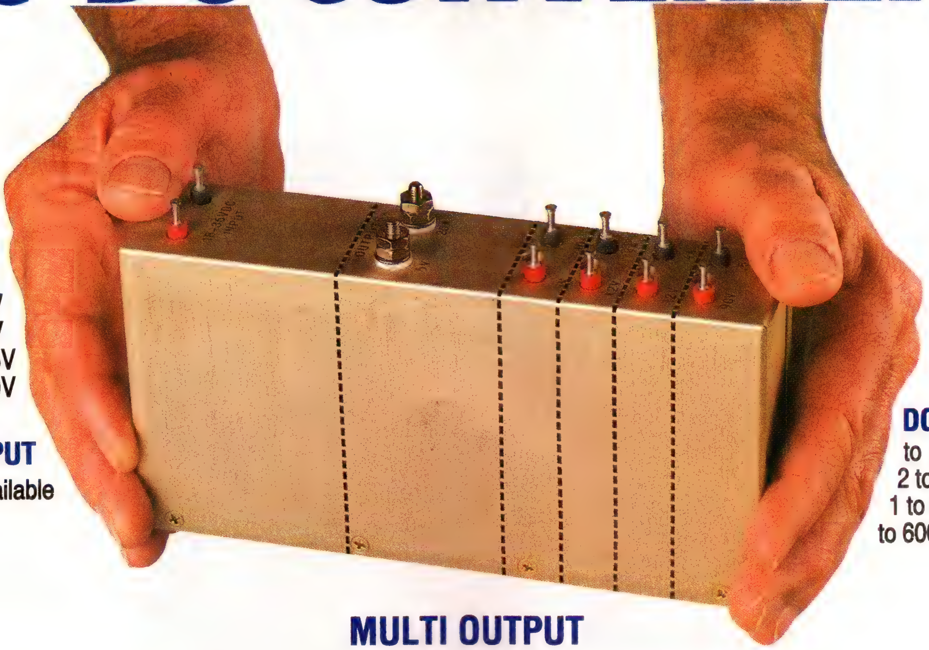

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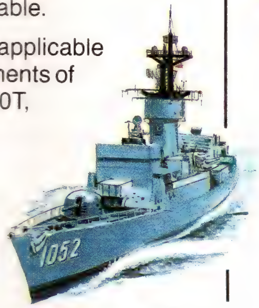

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CIRCLE NO. 39

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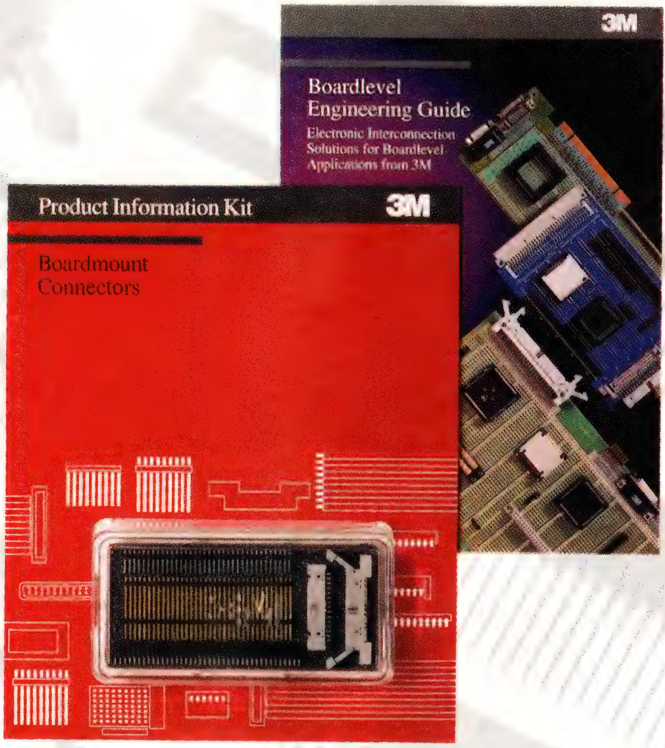
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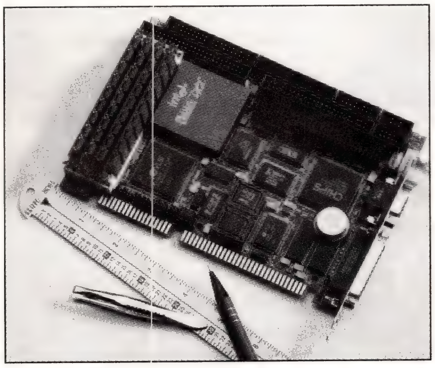
CIRCLE NO. 34

Fast tape drive uses enhanced parallel port. The Tape250 Parallel Port II external tape drive operates 50% faster than its predecessor by implementing the latest parallel-port specifications. It uses the IEEE 1284 parallel communications specification and is compatible with the bidirectional enhanced parallel port. The unit uses QIC-40 minicartridge tapes. $399. **Iomega Corp**, Roy, UT. (801) 778-1000. **Circle No. 336**

Tape drive stores 1.7 Gbytes on minicartridge. The Model CTM1360 tape drive connects to a computer via a floppy-disk interface and stores 1.7 Gbytes of data on a minicartridge. The drive is compatible with the QIC-3200 standard and is read-compatible with QIC-3010, QIC-80, and AccuTrak-250 formats. The 1.7-Gbyte capacity results from using data compression and QICWide 900-Oe media; native capacity (without compression) is 850 Mbytes. Data transfers occur at rates as high as 19 Mbytes/minute. $200 (OEM). **Conner Tape Products Group**, Costa Mesa, CA. (714) 641-1230. **Circle No. 337**



Half-size AT card has 486-based computer and SVGA. The Viper803 single-board computer, for stand-alone use in embedded systems or with a passive backplane, incorporates a 486 µP, SVGA, and a PC/104 mezzanine bus. It includes Chips & Technologies' 65535 video controller for CRTs and flat-panel displays, plus Standard Microsystems' SMC FDC37C665 combination I/O chip for high integration. Adaptec's 6360 SCSI controller chip provides a Fast SCSI 2 connection. From $1195. **Teknor Microsystems Inc**, Montreal, PQ, Canada. (514) 437-5682. **Circle No. 338**

SBus adapter enables ATM. With the ENI-155s single-slot SBus adapter, systems such as Sun SPARCstations and SPARCservers can perform asynchronous-transfer-mode communications. The adapter enables applications that integrate video, voice, and data. Available physical interfaces are full-duplex multimode fiber and unshielded twisted pair Category 5 at the synchronous optical network and synchronous digital hierarchy 155-Mbps rate. $1000 (OEM). **Efficient Networks Inc**, Dallas, TX. (214) 991-3884. **Circle No. 339**

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ISA card with 16 DSPs targets multimedia and telephony. $9995. **Ariel Corp**, (908) 249-2900. **Circle No. 340**

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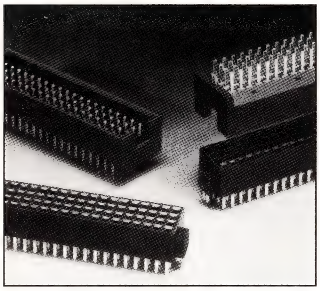
Gadget lubricates O rings with a twist. An O-ring lubricator consists of a flat circular case containing foam pads. The foam pads are charged with lubricant. Putting an O ring in the case and twisting the lid lubricates the O ring. Model 2.5-747, $6.95. **Frank Hillson**, Cupertino, CA. (408) 446-9660. **Circle No. 341**

Isolation transformers meet power-isolation, medical, and dental standards. The M4L series of high-power isolation transformers meets US and international requirements for power-isolation, medical, and dental standards. The transformers are one-third the size of previous transformers. The transformers come in 300-, 600-, and 1000-VA ratings. $44.50 to $95.50 (100). **Signal Transformer Co**, Inwood, NY. (516) 239-5777. **Circle No. 342**



Strip connectors come in three- and four-row versions. The MOLC and FOLC series of 0.050×0.050-in. connectors comes in three- and four-row versions featuring pin counts from five to 50 pins/row. These through-hole connectors have three-finger female contacts made from beryllium copper. Phosphor-bronze male contacts are shrouded. $0.10 per mated pair; delivery is seven days ARO. **Samtec Inc**, New Albany, IN. (812) 944-6733. **Circle No. 343**

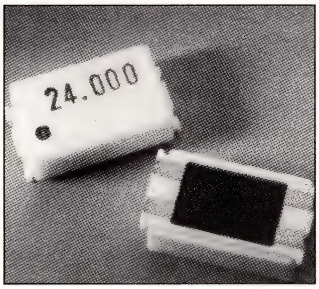
Surface-mount connector links flexible circuit to pc board. The FH12 series of miniature, surface-mount connectors joins flexible circuits to pc boards. The connectors have 0.020-in. conductor spacing and a 2-mm mounting height. The connectors are available in 10, 15, 20, 24, 30, 33, 36, 40, 45, and 50 positions. $0.46 to $0.91 (OEM quantities). **Hirose Electric**, Simi Valley, CA. (805) 522-7598. **Circle No. 344**

Heat exchanger saves space. The model 6340 fin-and-tube heat exchanger measures 27.5×22.2×7 in. Its temperature rating is 500°F. The exchanger handles liquid flow rates from 4 to 10 gallons per minute. The maker tests all units to 200 psig. $520; delivery from stock. **Lytron Inc**, Woburn, MA. (617) 933-7300. **Circle No. 345**

Two-way power splitter has 1.0° phase imbalance. The PQW-2-90 90° power splitter operates from 30 to 90 MHz. It exhibits 0.6-dB amplitude imbalance typ and 1.0° phase imbalance typ over this band. It features 27-dB isolation and a 1.1:1 VSWR. The splitter operates from –55 to +100°C. $24.95 (50); delivery, stock to one week ARO. **Mini-Circuits**, Brooklyn, NY. (718) 934-4500. **Circle No. 346**

Pressed-powder magnetic cores suit high-frequency applications. Super MSS pressed-powder magnetic cores exhibit a 10,000G saturation level because they have, in effect, an air gap distributed throughout the core. At high frequencies, the cores have lower losses than iron-powder cores do. The cores also suit unipolar-drive applications. The cores' diameters range from 0.50 to 10 in., and they come in four standard permeabilities of 125, 90, 75, and 60. $0.20 to $20. **Arnold Engineering Co**, Marengo IL. (815) 568-2000. **Circle No. 347**

Low-insertion-force connectors meet D55302. The KA/254 line of low-insertion-force, pc-board connectors is available in four- or five-row versions. Terminations include pc board, solder cup, crimp, and wrapped wire. Contact resistance is 5 mV max. The connectors' pins have 0.100×0.100-in. spacing. $36 to $250 (1000); delivery 14 to 16 weeks. **Hypertronics Corp**, Hudson, MA. (508) 568-0451. **Circle No. 348**



Oscillators come in surface-mount packages. The CO-2300 series of crystal-clock oscillators measure 8×4.5×2.3 mm. The units require 5V power and consume 30 to 75 mW. Output is a 50%-duty-cycle square wave capable of driving up to 10 TTL loads. The units operate from –10 to +60°C. You can choose ±30-, 50-, 100- or 500-ppm accuracies (room temperature). $2.60 to $4 (10,000); delivery, 10 weeks ARO. **Raltron Electronics Corp**, Miami, FL. (305) 593-6033. **Circle No. 349**

LED alphanumeric displays have auxiliary LEDs for decimal points and degree signs. Where other LED displays require an entire character position for a decimal point or degree sign, the IPD255x family of programmable LED displays has auxiliary LEDs for these functions. The displays come in red, green, and yellow. They measure 0.5×1.2 in. Each 0.25-in.-high character consists of a 5×7 array. The devices consume 150 mA max. $97 (100). **Siemens Components Inc, Optoelectronics Div**, Cupertino, CA. (408) 725-3423. **Circle No. 350**

Snubber capacitors mount directly to IGBT modules. The PMB series of capacitors' values range from 0.17 to 1.7 mF in voltage ratings from 850 to 1600V dc. The capacitors withstand dV/dt ranging from 250 to 750 V/μsec, and their operating temperature ranges from –40 to +85°C. $3.50 to $6 (5000). **Illinois Capacitor Inc**, Lincolnwood, IL. (708) 675-1760. **Circle No. 351**

High-speed-transmission cables match system impedances. A family of high-speed-transmission cables features silver-plated conductors and fluorinated ethylene-propylene (FEP) insulation. This insulation has a 2 to 2.2 dielectric constant. The flexible cables come in 50, 75, and 100Ω impedances with conductor pitches as tight as 0.0125 in. The cables are available in single-ended or differential-signal configurations and in shielded or jacketed designs. $0.01 to $0.05 per conductor per ft. Delivery, four to eight weeks ARO. **AMP Inc**, Harrisburg, PA. (717) 564-0100. **Circle No. 352**

Surface-mount unit functions as flyback transformer, pulse transformfer, or high-energy inductor. The Power-Pak surface-mount toroidal transformer functions as a wide-range flyback transformer, a 1:1 pulse transformer, or a high-energy inductor. The unit has a 1-MHz bandwidth. $3 to $7.50 (OEM quantities). **GFS Magnetics**, Dover, NH. (603) 742-4375. **Circle No. 353**

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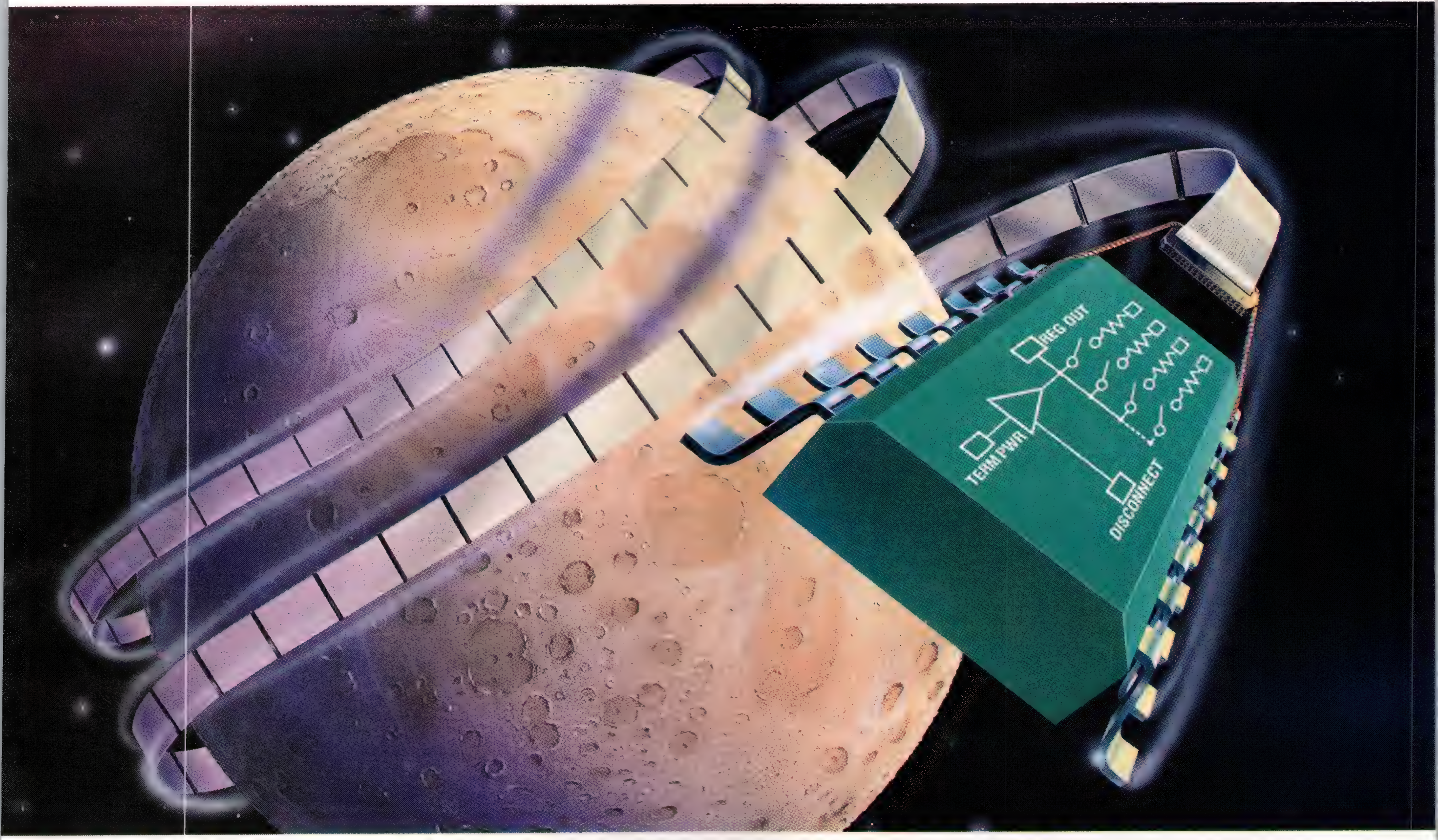

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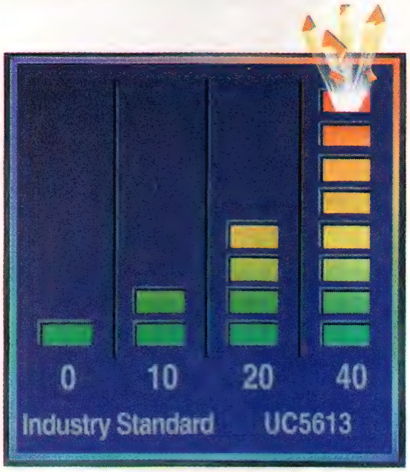

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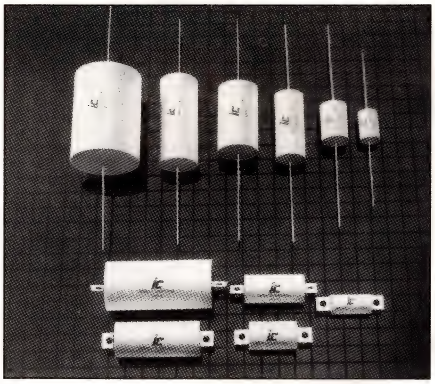
CIRCLE NO. 87

Fast filter turns black-and-white displays into color. The RGB Fast Filter is an electrically switchable RGB color filter that turns black-and-white CRT displays into color displays. The filter's 1.16-in. clear aperture suits applications such as helmet-mounted viewers and virtual reality. The filter has a 100-µsec transition time between any of the colors and requires a ±5V control signal. The filter allows display of each of the three color fields three times during the normal 60-Hz scan. $950 (singles); delivery, stock (custom designs take eight weeks). **Displaytech Inc**, Boulder, CO. (303) 449-8933. **Circle No. 354**

500W to 3 kW rectifiers recover in 100 to 170 nsec. Power rectifiers in SOT-277, screw-terminal packages encapsulate two devices and offer 2.5-kV isolation. The package has <5-nH inductance and 0.27°C/W thermal resistance. Regular diodes come in 400 and 1000V models; Schottky rectifiers, in 45, 60, and 100V models. $10 to $12 in production quantities; delivery, eight weeks ARO. **Motorola**, Phoenix, AZ. (602) 244-3071. **Circle No. 355**

Motor-control relay squeezes down to fit on pc boards. The G4A relay handles the high inrush currents of motors, compressors, and inverters. Its single form-A (SPST NO) contact ratings are 20A, 250V ac, for 100,000 operating cycles and 100A inrush current. The relay is available with through-hole or push-on terminals. The relay measures 1.2×0.63×0.93 in. $5.30 to $5.68; delivery, stock. **Omron Electronics Inc**, Schaumburg, IL. (708) 843-7787. **Circle No. 356**

Unique crystals oscillate at fundamental frequencies ranging from 60 to 200 MHz. The HFX series of quartz crystals has fundamental frequencies as high as 200 MHz; overtone frequencies range to 622 MHz. The crystals come in 2×5-mm tubular packages or UM1/HC45 metal packages. Available tolerance ranges (at +25°C) are ±25, ±50, or ±100 ppm. Tubular packages typically have temperature stability of ±25 ppm from –40 to +85°C. $3 to $20. **Saronix**, Palo Alto, CA. (415) 856-6900. **Circle No. 357**



Filter capacitors soothe switchers. The MPH/MPL series of capacitors comes in an axial-lead, flame-retarding package. Type MPH comes with standard leads, and type MPL come with lug terminals. Capacitances range from 1 to 30 µF. The capacitors handle ripple currents of 15 and 30A, respectively, (dV/dt=10 V/µsec), and their dissipation factor measures ≤0.01% at 1 kHz. Working voltage ranges from 100 to 400V dc. $0.45 to $5.45 (1000). **Illinois Capacitor Inc**, Lincolnwood, IL. (708) 675-1760. **Circle No. 358**

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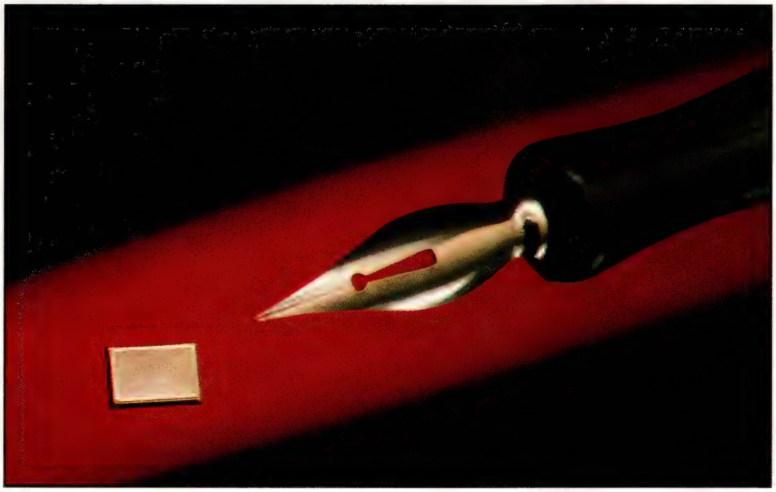

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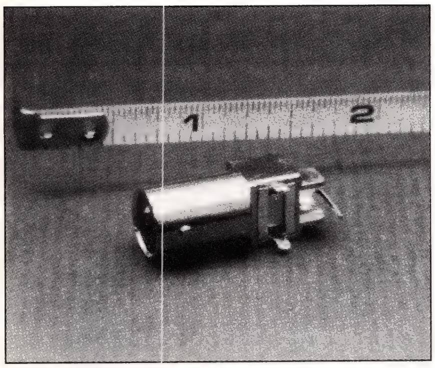

BNC jack hugs pc board. The super-low-profile right-angle BNC jack, 364M595M, boasts nickel-plated, zinc-alloy construction. The jack's phosphor-bronze contact has 15-μin. gold plating. $3.50 (small quantities); delivery is from stock. **Bomar Interconnect Products Inc**, Ledgewood, NJ. (201) 347-4040. **Circle No. 359**

Solid-state relay drops on-resistance to 22Ω. The model PLA110 (one form-A contact) and PAA110 (two form-A contacts) solid-state relays come in six- and eight-pin DIPs and surface-mount packages. The units feature 400V load voltage, 150-mA peak current, and 22Ω on-resistance. The units are available with 3750V-rms isolation and agency approvals. $2.17 (1000); delivery, stock to eight weeks ARO. **CP Clare Corp**, Wakefield, MA. (617) 246-4000. **Circle No. 360**

Modular connectors link PCs to ISDN. Available in six- or eight-pin versions, the TM11 connector replaces unshielded RJ-45 jacks. The jack's plastic-covered metal shield engages before signal pins do upon mating. The plastic covers come in beige, black, or gray. A right-angle plug is also available. TM11 plug $1.25 (10,000); shielded jacks, $1.75 to $3.25 (10,000). **Hirose Electric Inc**, Simi Valley, CA. (805) 522-7958. **Circle No. 361**

Small, stick-on labels record maximum temperature. The CelsiClock stick-on labels accurately and irreversibly indicate the maximum temperature reached by any device to which the labels are attached. The labels measure 9/16 in. in diameter and contain five temperature-sensitive circular areas arranged like the cylinders in a revolver. If the temperature exceeds the rating of any circle for even a fraction of a second, that circle turns from clear to black permanently. Yellow digits within each circle that indicate a circle's temperature rating become visible over temperature. The indicators are available in eight ranges from 105 to 500°F (40 to 260°C). $0.95 to $1.35 (10 to a pack) or $0.82 (roll of 1000). **Solder Absorbing Technology Inc**, Springfield, MA. (413) 788-6191. **Circle No. 362**

Solid tantalum chip capacitor suits switch-mode power supplies and dc/dc converters. The 593D series solid-tantalum chip capacitor comes in molded, surface-mount packages (EIA sizes 7343 and 7343H). The capacitance range is from 10 to 220 μF. Working voltages are 6.3, 10, 16, 20, 25, and 35, and operating temperature is –55 to +85°C (+125°C with derating). The capacitors' ESRs range from 0.100 to 0.300Ω, and maximum ripple current ranges from 0.71 to 1.28A. 1000-μF device $0.589 (1000); delivery is six to eight weeks ARO. **Sprague**, Sanford, ME. (207) 324-4140. **Circle No. 363**

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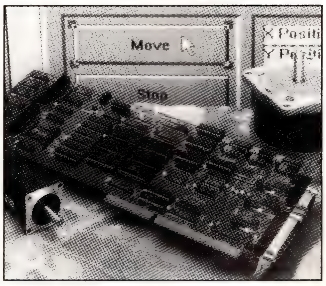
CIRCLE NO. 48

Miniature photoelectric sensor provides proportional voltage output. The LPAN-1 sensor responds to visible red light (660 nm). The unit has a 1 to 8V-dc output at 3 mA max. The output-response time is 1V/msec. The brightness of the unit's LED corresponds to the intensity of the received signal. The unit requires 12 to 24V dc at 40 mA and comes in an IP40 ABS resin case. $158 (singles). **Dolan-Jenner Industries**, Lawrence, MA. (508) 681-8000. **Circle No. 364**

SAW filter recovers OC-12 SONET clock. The BP1045 SAW (surface acoustic wave) filter has a center frequency of 622.08 MHz and a nominal loaded Q of 800. The filter suits OC-12 SONET clock-recovery applications. The filter connects to 50Ω source and load impedances without using matching components. The surface-mount filter measure is 7×9×2 mm. $30 (100). **RF Monolithics**, Dallas, TX. (214) 233-2903. **Circle No. 365**



Visual-programming development system directs servo and stepper motors in real time. The Servo/Stepper Application Workbench V2.0 works with the SI-3000 motion-control board under Microsoft Windows. The board controls one to nine servo or stepper motors at a count rate of 2 MHz max (8 MHz optional) at sample rates to 2 kHz. Development software costs $1495. The SI-3000 ranges from $845 (one axis) to $2970 (six axis). **Douloi Automation**, Campbell, CA. (408) 374-6322. **Circle No. 366**

Logic-delay line is programmable. You program the PFLDL delay at any time, in-circuit, using line-three control bits. The device has 23 delay taps having resolution from 0.5 to 50 nsec. The device provides 355-nsec delays max from a 14-pin DIP. The device comes in through-hole and surface-mount packages. $14 (100); delivery, stock to four weeks ARO. **Engineered Components Co**, San Luis Obispo, CA. (805) 544-3800. **Circle No. 367**

Lightning protector helps keep ATMs honest. The model 2356 lightening protector for four-wire (dual-twisted pair) telecommunications or ISDN links prevents lightning surges from causing data errors, equipment damage, or personal injury. The unit has a fast-acting series 250-mA fuse, a shunt 1500J gas-discharge tube, a series inductor, a pair of shunt avalanche diodes, and a series resistor. The unit meets UL1459 requirements. It measures 4.6×1.7×1.3 in. $97 (10); delivery, stock to three weeks. **Telebyte Technology Inc**, Greenlawn, NY. (516) 423-3232. **Circle No. 368**

Complete modem comes in 0.5×1×1.25-in. package. The CH1785 is a 2400-bps, V.22 bis modem that is Hayes-AT compatible. The devices requires 5V power. $29.95 (1000). **Cermetek Microelectronics Inc**, Sunnyvale, CA. (408) 752-5000. **Circle No. 369**

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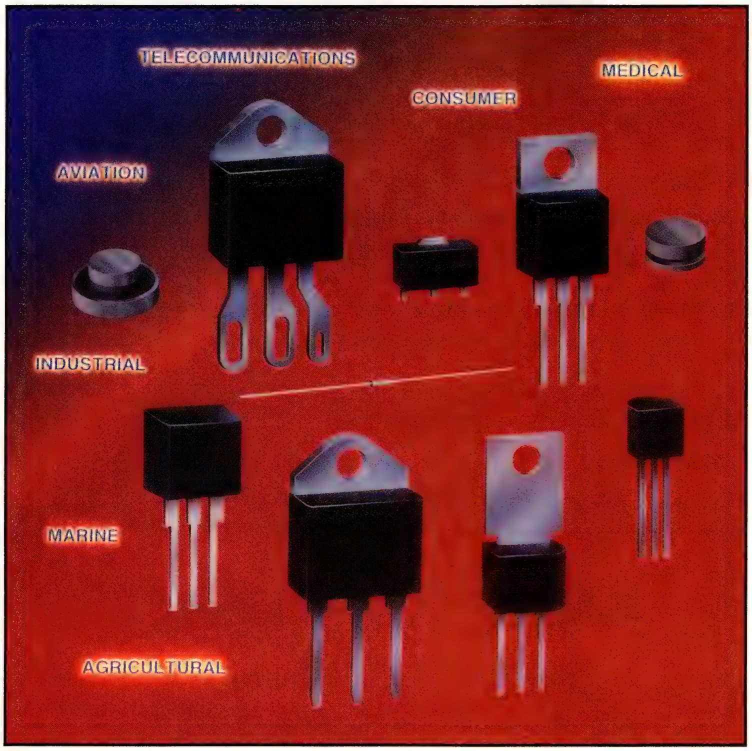

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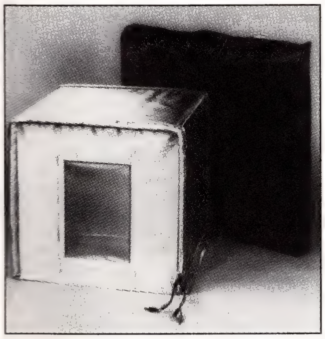
Fault locator for pc boards combines in-circuit testing with analog signature analysis. Using a single setup, the $9995 TD8000 makes in-circuit digital functional tests on devices having up to 40 pins and performs V-I-trace testing (or analog signature analysis) on 128 channels. These closely related functions, which enable you to locate and confirm device faults, previously required separate testers and duplicate setup procedures. **Polar Instruments Inc**, Sumas, WA. (206) 599-1430.
Circle No. 390

$79.95 handheld DMM resolves 10 nA ac or dc. The 3½-digit DM410 displays digits 0.91-in. high. You select ranges and functions with a knob. In addition to a "common" input jack, the meter has jacks for volts/ohm/diode-test, amps, and milliamps/microamps. When the device uses the milliamp/microamp jack, the most sensitive ac and dc current ranges are 20 μA. A one-digit change on these ranges represents 10 nA. **Universal Enterprises Inc**, Beaverton, OR. (503) 644-8723. **Circle No. 391**

IC test systems test at 16 sites in parallel. Testers in the 9490B Series use the vendor's HP 9000 Series 700 workstations as controllers. The controllers' ability to perform complex DSP functions without using a dedicated array processor obviates the need to transfer data between the controller and an array processor. The resulting timesaving increases the throughput of devices. $800,000 to $2 million. **Hewlett-Packard Co**, Santa Clara, CA. (800) 452-4844. **Circle No. 392**



Metallized-fabric enclosures simplify equipment shielding. These collapsible Faraday Cages make it easy to transport an equipment shield to where EMI may be affecting an instrument's operation. In addition to custom sizes and an 8×8×6-ft collapsible room, the vendor offers an 18-in. cube for $1000 and a 24-in. cube for $1300. **Zippertubing Co**, Los Angeles, CA. (310) 527-0488.
Circle No. 393

Serial-communication analyzer works alone or with a PC. The SCA+ captures up to 8192 bytes of data plus six lines of status information, all of which it can download to a PC or display on a four-line, 80-character LCD. The unit, which captures and transmits at speeds to 115.2 kbps, can limit capture to specific messages. Capture modes include all data, N bytes, only when certain flow-control lines are active, after a "start" sequence, and until an "end" sequence. You can combine these modes. $495. **Dactronix**, Rolla, MO. (314) 364-0193.
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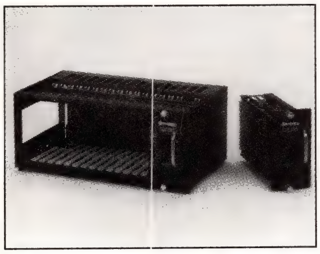

STD enclosure offers removable power supplies. The ZT 210 series of STD 32 card cages includes power supplies that you can insert and remove from the front panel. The supplies offer 5, 12, and 3.3V options; front-panel access to ac or dc input power; status indicators; and reset and on/off switches. The cages range from nine- to 21-slot widths and offer a choice of wall-mount, rack-mount, and tabletop styles with optional forced-air cooling. Prices begin at $600. **Ziatech Corp**, San Luis Obispo, CA. (805) 541-5088. **Circle No. 395**

Adapter links PCI to VME systems. Comprising a PCI-PC add-in card, a 6U VME card, and a shielded cable, the Model 617 adapter links a PCI-based PC to a VME system. The adapter provides memory mapping, allowing each system to see the other as part of its memory space, and offers dual-port RAM for shared memory. The adapter also maps interrupts onto one another and provides a DMA controller for block transfer. You can use the board to control a VMEbus system from a PC without requiring a processor module on the VMEbus. Price is $1850. **Bit3 Computer Corp**, Minneapolis, MN. (612) 881-6955.
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VME accelerator adds to SPARCstations. The SkyStation II accelerator connects to SPARCstations running Solaris through the SCSI-2 interface. The accelerator contains VME boards with multiple RISC processors operating in parallel. The processors communicate over a 320-Mbyte/sec packet bus and provide a combined processing power of 640 MFLOPS. Software-development tools for the accelerator include a math library for parallel execution; compilers that automatically vectorize code; and C, FORTRAN, and Ada compilers. Prices range from $20,000 to $50,000, depending on configuration. **Sky Computers Inc**, Chelmsford, MA. (508) 250-1920.
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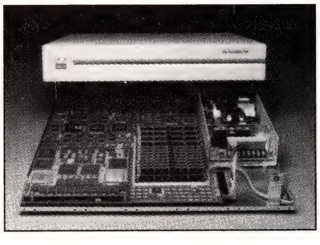

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September 15	August 17	• Wescon/Embedded Systems • Microprocessors
September 29	August 31	• Test & Measurement • Crystals & Oscillators
October 13	September 14	• Portable Equipment Design • PLDs • FPGAs
October 27	September 28	• Digital Signal Processing • Embedded Tool
November 10	October 12	• Computer & Peripherals • A/D-D/A Convention
November 24	October 26	• Quality in Design • Connectors • H/W & S/W
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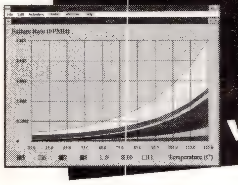

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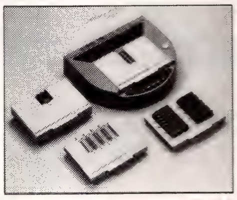

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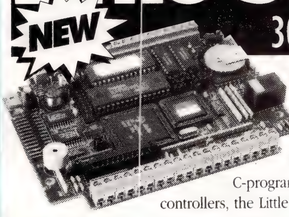

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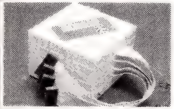

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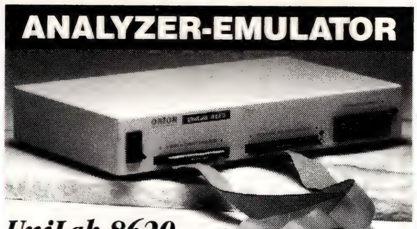

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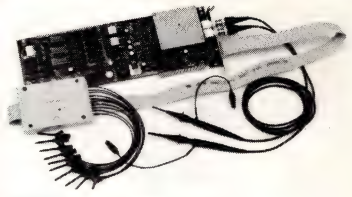

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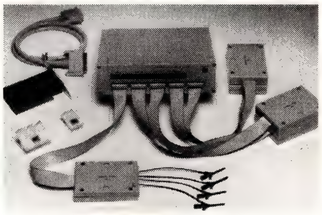

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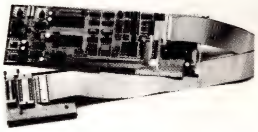

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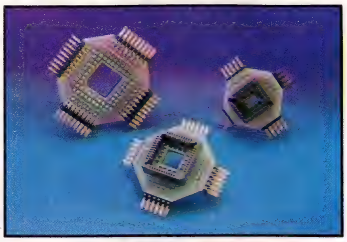

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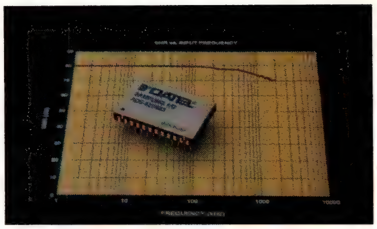

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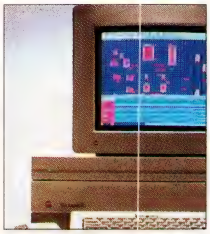

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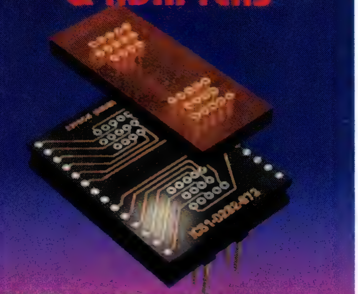

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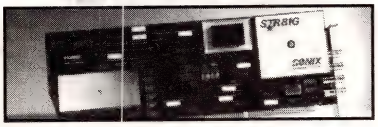

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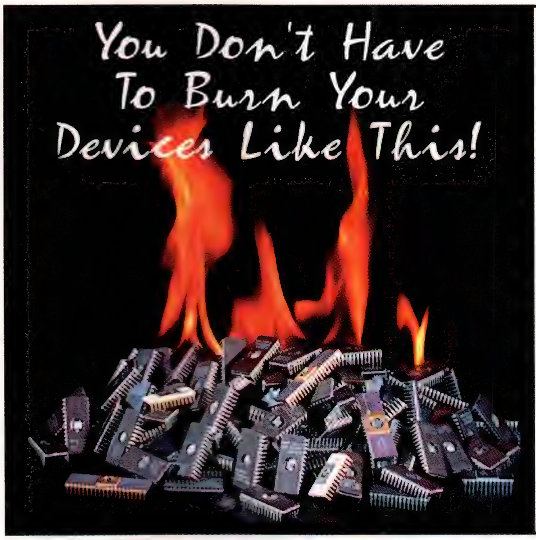

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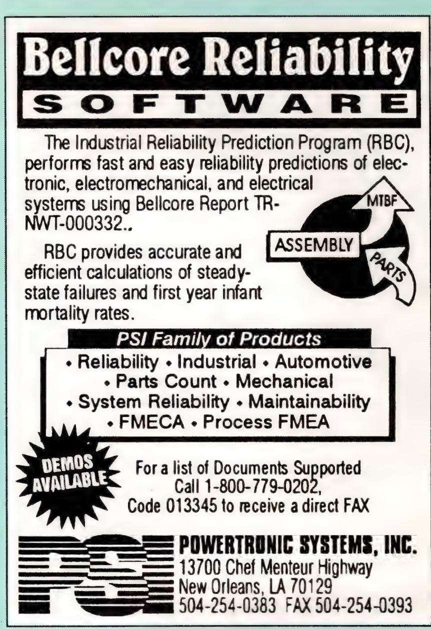

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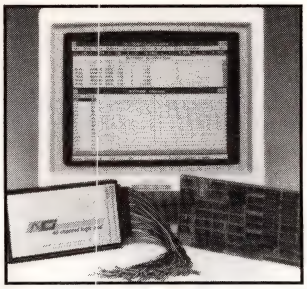

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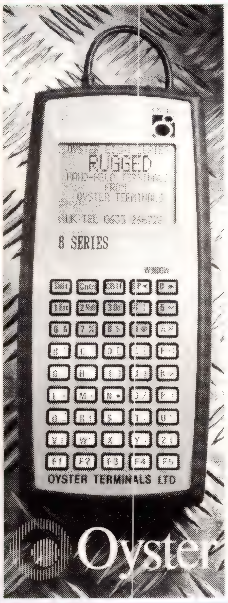

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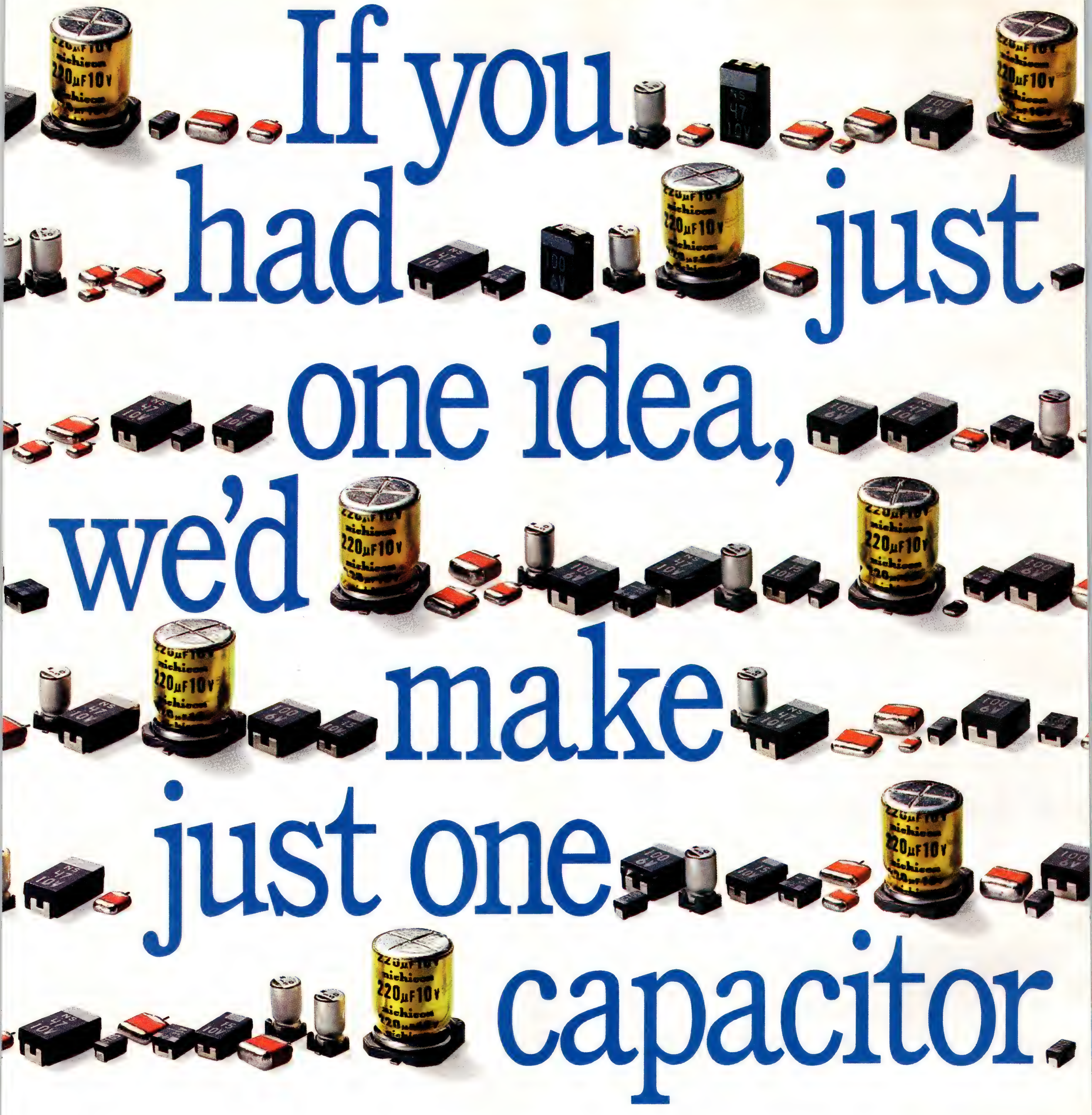

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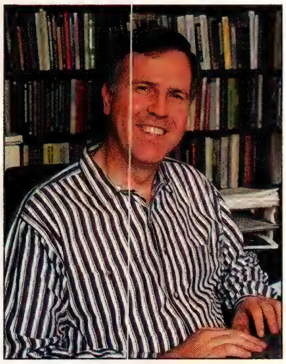

DAVID BRUBAKER, FUZZY-LOGIC CONTRIBUTING EDITOR

Everyday life can get fuzzy

"Question Authority." Seeing the bumper sticker last week was like a flashback to the late 60s. Then, as now, the implied defiance made me enjoy even more the story of the conservative professor who, upon entering his classroom and seeing the phrase written in large letters across the chalkboard, calmly wrote beneath it, "And listen to the answer."

Another bumper sticker I regularly see on a car whose owner frequents the coffee shop around the corner is "Subvert the Dominant Paradigm." While I often 'question' the dominant paradigm, 'subvert' is too strong for me. I prefer evolution of knowledge, augmented with occasional leaps of brilliance. I especially enjoy the leaps—for example the genius of "I understand that the square root of –1 is impossible, but let's see what we have if we define a number system where it is not."

> **When used appropriately, fuzzy logic allows us to eschew the obfuscation that often crops up in engineering design.**

Fuzzy logic is such a leap. In some ways it seems counterintuitive. As we engineers strive to measure and model with ever greater accuracy, that we would intentionally elect to move toward less precision makes no apparent sense. It definitely doesn't fit the dominant paradigm. But it does fit how we live our everyday lives.

Describe the next person you see. Looking out my office window, I see a man, fairly tall and very skinny. He is young, between 18 and 20, no more than 24, and has long, stringy, brownish-blonde hair. His eyes are deep-set and widely spaced. He walks slightly stooped.

This description is a model of a person, a word-based model. The model is riddled with imprecision, in words such as 'tall,' 'skinny,' 'young,' 'long,' 'deep-set,' 'widely,' and 'stooped.' Even the attempt to get specific, 'between 18 and 20' is qualified with 'no more than 24.' Would I be surprised if he were 25 or even 26? Not really. In the entire description, there is only one fact: that he is male. The rest are fuzzy terms.

And yet we all have a general sense of what this man looks like. We accept this imprecision and work with it, realizing it is the product of our visual system's inability to give more precise measurements. We also recognize our inability to infer correctly—in this case, age from general appearance—as well as, perhaps, our memory's inability to recall detail. Unable to quantify with numbers, we work quite comfortably with words. The fuzzy model is more accurate than having no model at all.

When Lotfi Zadeh first formulated fuzzy set theory and fuzzy logic, he did so because systems he worked with were becoming sufficiently complex as to be intractable with numeric representations. Rather than throwing up his hands in dismay, he looked for an alternative. The alternative—his leap of brilliance—came with his willingness to sacrifice precision to obtain a workable model. It was a worthwhile tradeoff.

What he needed was a mathematical basis. Professor Zadeh looked to set theory, but quickly realized that traditional set theory, which requires an element to be either fully a member or not a member of a set, was inadequate. If, for instance, we define a set 'tall' for a North American male to include anyone over 6 ft 3 in., how about the man who stands 6 ft $2\frac{7}{8}$ in.? He is, by definition, 'not tall.' Professor Zadeh felt this was counterintuitive and would be inadequate when linguistically modeling his complex systems.

So he formulated fuzzy set theory, allowing an element simultaneously to be partially a member and partially not a member of a given set. You can now represent the term 'tall' as a finite sloped function, with its x-axis representing all possible heights, and its y-axis the degree to which a given height is a member of the set. The 6-ft $2\frac{7}{8}$-in. man can be 98% 'tall'; he is also 2% 'not tall.' This makes much more sense.

At the foundation of this word-based modeling process is what Professor Zadeh calls linguistic variables. As engineers, we often work with numeric variables, which are symbols or storage elements that can be assigned numbers as their values. Linguistic

PHOTOGRAPHY / LIANE ENKELIS

variables are symbols or storage elements that are assigned words as their values. A traditional variable 'height' would include numeric values such as 5 ft 2 in. and 6 ft 6 in.; a linguistic variable 'height' includes values such as 'short' and 'tall.' Linguistic variables are fuzzy variables, and the values of a fuzzy variable are called fuzzy values. As an example, let's discuss tall, a fuzzy value of the variable height, again taken in the context of a North American male.

First, we define tall as a collection of points placed at 1-in. intervals between 67 in. (5 ft 7 in.) and 77 in. (6 ft 5 in.). For each height in this range, we assign a degree of membership, typically designated µ, that indicates how well each numeric (or crisp) height fits into our fuzzy set 'tall.' The convention is to say that if it doesn't fit at all, µtall=0, and if it fits completely, µtall=1. Assigning degree of membership is subjective. You can consult an expert or base it on the results of a survey. You can also base it on system constraints. Arbitrarily, for this example, we shall say a 69-in. man is not tall, and that 69 in. has zero degree of membership in the fuzzy set 'tall.'

Use the expression µtall(69 in.)=0.00, which reads "the degree of membership of 69 in. in the set 'tall' is 0." The height 75 in. has full membership in the set 'tall': µtall (75 in.)=1.00 or "the degree of membership of 75 in. in the set 'tall' is 1." The height 6 ft even (72 in.) is at a point of maximum ambiguity; it is equally 'tall' and 'not tall': µtall(72 in.)=0.50. Defined in this manner, **Fig 1** shows the fuzzy discrete set 'tall.'

If you use a function to represent the set, it's called a membership function. **Fig 2** shows two possible functional representations of the fuzzy set 'tall.' One is piecewise linear; the other is based on the hyperbolic tangent function, tanh. Piecewise linear functions, being simpler and computationally less intensive, are often used in real-time control applications. Functions based on tanh, or on one of several other similar smooth functions, are most often used in nonreal-time analysis applications.

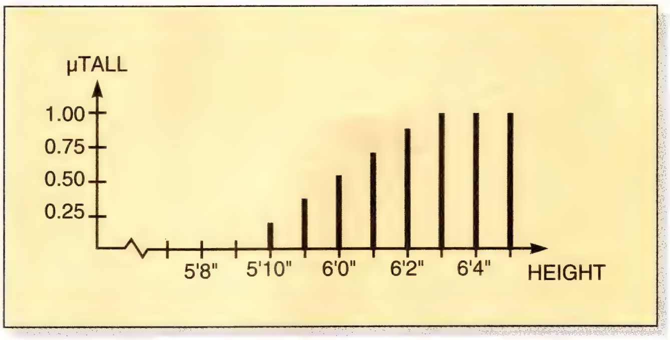

Fig 1—This graph illustrates a discrete, point-by-point representation of the fuzzy set 'tall.' The vertical coordinate, µtall, is called the degree of membership and is the degree to which each element on the horizontal axis is a member of the set 'tall.' For example, 5 ft 9 in. is not a member at all (µtall=0), 6 ft 3 in. is fully a member (µtall=1), and 6 ft 0 in., having a degree of membership, µtall=0.5, is equally a member and not a member.

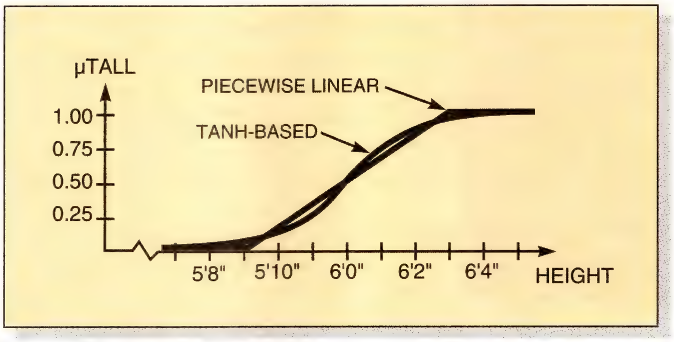

Fig 2—The graph above shows two continuous representations of 'tall.' Because of its simplicity, the piecewise linear version is most often used in real-time control applications. The hyperbolic tangent (tanh) versions above are examples of smooth functions that are most often used in nonreal-time applications, as in fuzzy analysis programs.

Fuzzy logic is closely linked to fuzzy set theory. The 72-in. height that belongs to the fuzzy set 'tall' with degree of membership 0.5, corresponds directly to the statement "72 inches is tall," having a 0.5 truth value—that is, being 50% true. Degrees of membership in fuzzy set theory are equivalent to truth values in fuzzy logic, and often you'll hear the terms used interchangeably.

How would we use all this in a practical application? Based on verbal descriptions, you can use fuzzy logic to greatly reduce the number of mug shots that crime victims and witnesses must review.

Let's say the man I described earlier turned out to be a mugger. It's not reasonable to expect my memory and descriptive ability to be precise enough to identify an individual based on a verbal description alone. However, if the search capability of a database of known muggers were fuzzy, the list of possible suspects could be greatly reduced. Each database entry would be compared with each of my fuzzy descriptive phrases, resulting in a collection of truth values. If a known mugger were 5 ft. 2 in., he would be 'fairly tall' with truth value zero. So would someone who is 6 ft 10 in. But an individual who is 6 ft 1 in. would match with unity truth value.

The resulting truth values are combined using a fuzzy-logic AND operator, most often implemented as a minimum, because a poor match on one point is sufficient to make the overall match also poor. A 22-year-old man who is 6 ft 1 in. with shoulder-length, light-brown hair, and widely spaced, deep-set eyes—but who weighs 250 pounds—is eliminated as not being 'very skinny,' despite the fact that the rest of his features accurately matched the description.

Next month we'll introduce the fuzzy rulebase and its use in setpoint control.

One final bumper sticker of note—and one of my favorites: Eschew obfuscation. Avoid that which bewilders. When used appropriately, fuzzy logic allows us to eschew the obfuscation that often crops up in engineering design.

David Brubaker is president of Huntington Advanced Technologies, 883 Santa Cruz Ave, Suite 31, Menlo Park, CA 94025-4608; or on the Internet at: brubaker@cup.portal.com.

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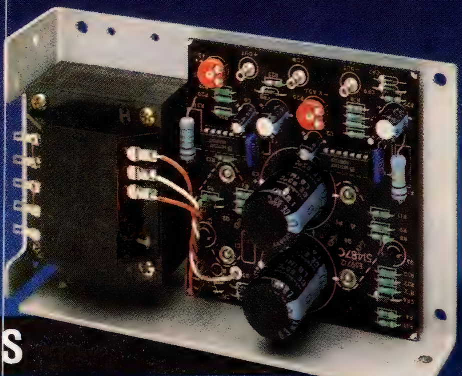

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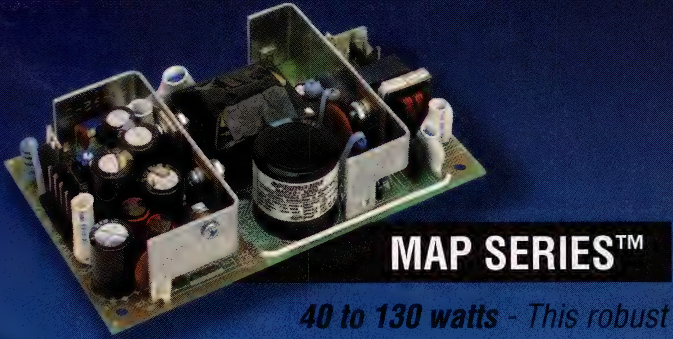

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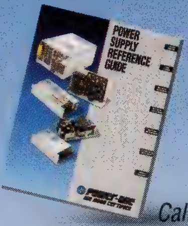

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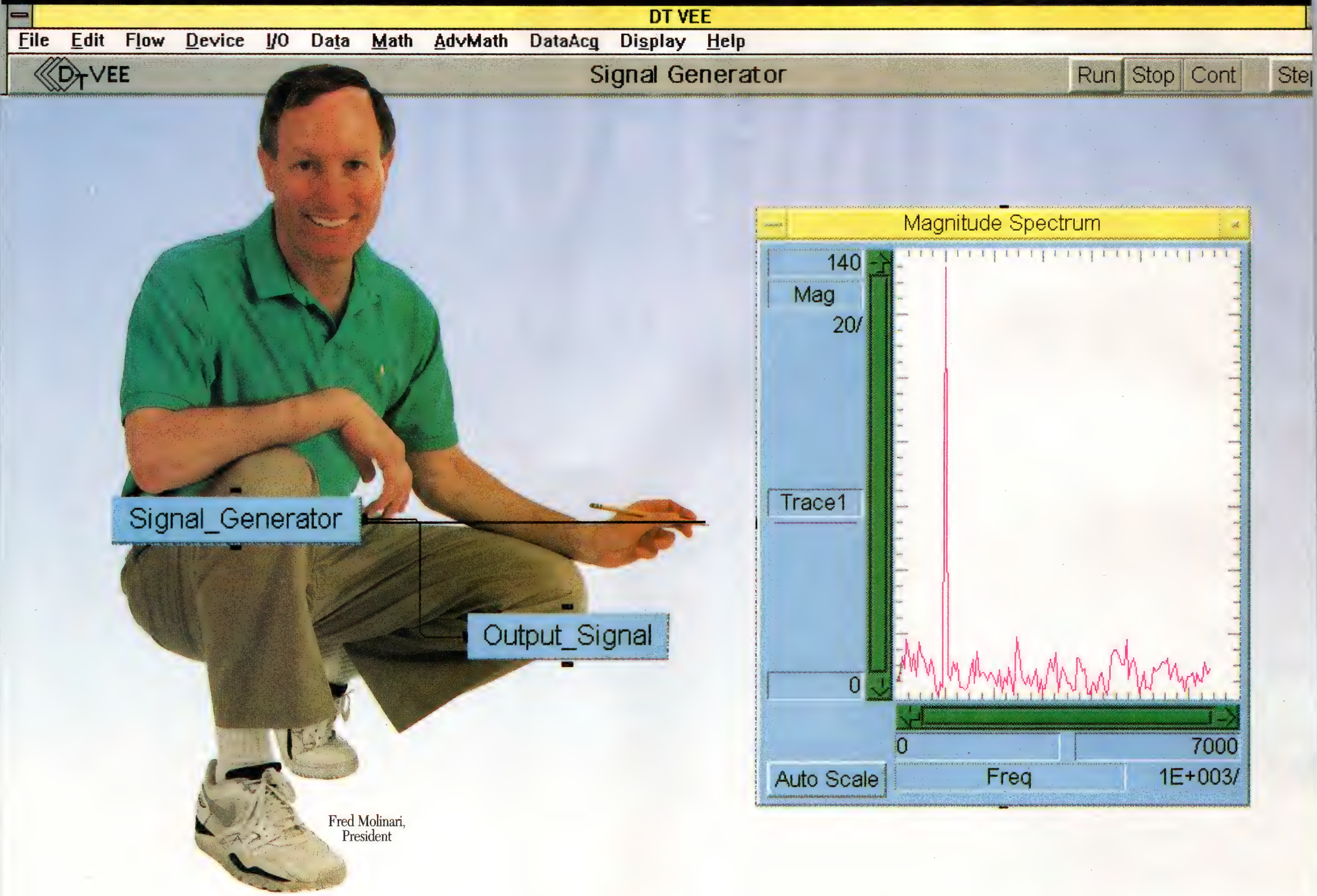

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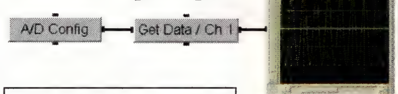

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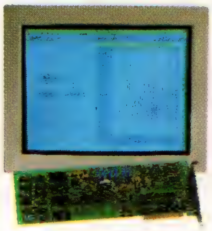

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East has reason to be proud of how his industry group, PREP, a nonprofit consortium of 14 companies, mostly FPGA houses, managed to hammer out its intracompany differences to create an honorable FPGA benchmark.

Sure, marketing managers from the FPGA companies, armed with the techniques satirized in that MBA-school, must-read classic, *How to Lie with Statistics*, still try their best at manipulating the publicly available PREP benchmarks. But, the truly near-criminal FPGA marketing lies/advertisements have stopped.

This forced the poor FPGA vendors to concentrate on actually providing measurable value to keep their customers. It's been painful, but, as a result, FPGA customers are continually offered better FPGAs that have higher speed, more capacity, and low prices.

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Encouraged by this success, PREP decided to create a special subcommittee called Working Group 4 (WG-4) chartered with the controversial task of benchmarking the synthesis tools used to design these newly available high-capacity FPGAs. Little did they know what resistance they'd get!

EDA-vendor reservations

"They're trying to get at synthesis benchmarking on unrealistically small, contrived designs that aren't representative of the top-down design process," says Alain Hanover, CEO of ViewLogic, a PC-oriented EDA vendor. "In place of using single, tiny data-path, state-machine, and combinational-logic subdesigns as a basis of synthesis benchmarking [which was what WG-4 considered], real-world designs are actually far larger combinations of these subdesigns. Synthesis is a very subjective thing to try to measure; it depends on your approach. Instead, I'd like to see benchmarking of top-down design processes where they measure results a designer gets working from a specification, writing Verilog or VHDL, and then going through a suite of tools to get to his final design."

I saw this as a red herring because benchmarking top-down design processes is even more of a subjective undertaking. Too much depends on how the designer interprets the specification, how he writes his HDL, and his ability to then skillfully handle the FPGA-synthesis and place-and-route tools.

Ewald Detjens, CEO of Exemplar, a company that specializes in both FPGA and small-ASIC synthesis observes, "The EDA-synthesis market leaders are paranoid about benchmarking because they think they can only lose with them. The FPGA companies and many of their customers aren't synthesis-literate. There's a serious education issue here if they're going to be running benchmarks because we EDA companies have to live with these benchmark results whether they're done well or poorly."

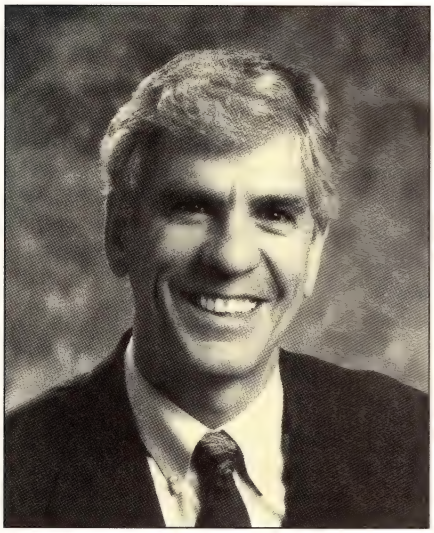
WG-4 wimps out

Facing this resistance from the EDA-synthesis vendors, WG-4 originally wimped out by disclosing that it did not plan to run FPGA-synthesis benchmarks or to publish any results. Instead, WG-4 planned to mimic the benchmarking cop-out that ACM's SIGDA offered some time ago: Present a collection of publicly accessible designs and let the customers perform their own "at-home" benchmarks. (That is, don't report any results.)

PHOTOGRAPHY / KEVIN BRYAN

The WG-4 designs were originally only in VHDL. WG-4 would also provide test benches so users could modify the VHDL to fit the vagaries of each brand of FPGA-synthesis tools being tested. (VHDL is not one hardware-description language, but a collection of very closely related hardware-description languages.) The FPGA-synthesis vendors liked this compromise/capitulation offered by WG-4 because there would be no benchmark reporting and the user would be forced to look at each FPGA-synthesis vendor's product—enabling the vendor's sales staff to sweet-talk a sale. It was *business as usual.*

Then the press had its turn. Some of the PREP representatives from Synopsys, Exemplar, Xilinx, and Altera tried to defend the "synthesis-is-too-complicated-so-let's-not-benchmark-it" stance. But, EDA troublemakers Mike Dini, Sean Murphy, and I chanted a collective "Wimp! Wimp! Wimp!" in the *EE Times* article that announced the WG-4 cop-out. This, plus quite a few other people's behind-the-scenes actions encouraged WG-4 to successfully brainstorm ways to solve their FPGA-synthesis benchmarking issues.



John East, head honcho of Actel, says "I think an imperfect benchmark is better than none."

WG-4 revitalized

In place of the using the simple step-and-repeat of simple circuits that didn't give many FPGA-synthesis tools a chance to shine, John Birkner, chairman of WG-4 and vice president of Quicklogic, reported that WG-4 was thinking of offering a series of benchmark designs that became gradually larger. This would enable the user to determine how effectively the FPGA-synthesis tool utilized FPGA space.

The designs, available on Internet, would range from 1000 to 10,000 gates from a cross section of functionality and market segments of real-world designs recruited by the 10 FPGA vendors from their customers. *More important, EDA vendors, FPGA vendors, and users could benchmark these designs and publicly report their results plus the exact synthesis-tool settings they used on the same Internet site.*

Talk of having standardized place-and-route settings was kicked around. Also, realizing it's bad business to alienate ASIC designers *who are primarily Verilog users* (plus finding out that it's not hard to translate from synthesizable Verilog to synthesizable VHDL and vice versa), WG-4 will offer designs and test benches in Verilog.

Many of the WG-4 members voiced their preferred strategy of embarrassing the 10 FPGA vendors and 10 FPGA-synthesis vendors into partaking in the benchmarks. That is, if Synopsys refused to have their tools or AT&T refused to have their FPGAs involved in this synthesis benchmark, their absences would be rather conspicuous.

"Instead of playing Big Brother, WG-4 plans to use the 'carrot-but-no-stick' approach to get industry cooperation," says Steve Sharp, Xilinx's WG-4 representative.

Uncle John wants YOU

Keep in mind that WG-4 is still in the formative stage for much of this, and Birkner wants your ideas and help. (He can be contacted at "john@qlogic.com" or (408) 987-2020.) Exactly how will benchmarks be reported? What if Minc benchmarked Data I/O and reported suspicious results, making Data I/O look bad? What if Innovative Synthesis Technologies reported unrealistically good results with its tools that no one else could duplicate? Should there be a public record of who tried to report what results that were deemed questionable by the WG-4 and why they were rejected? How can they get lots of users to be a part of this undertaking instead of just companies defending their vested interests?

No matter how you answer these questions, you'll still have those who "lose" in the benchmarks howling that the benchmarks were somehow flawed in the first place.

"Yes, everyone wants a benchmark that makes their own silicon or synthesis product look good," says East, "but I think an imperfect benchmark is better than none."

John Cooley, an EDA consumer advocate and founder of the outlaw E-mail Synopsys Users Group (ESNUG), lives on the Holliston Poor Farm in Massachusetts. He raises sheep and is an EDA- and ASIC-design instructor and project-in-crisis consultant. He can be reached at "jcooley@world.std.com" or at (508) 429-4357.

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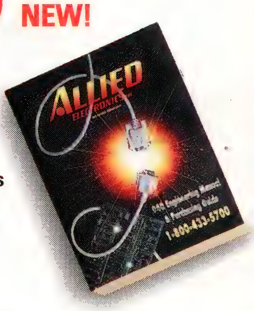

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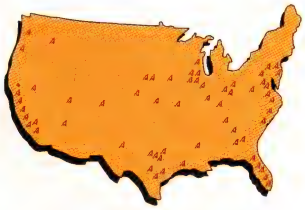

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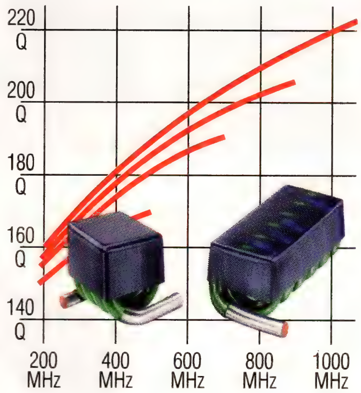

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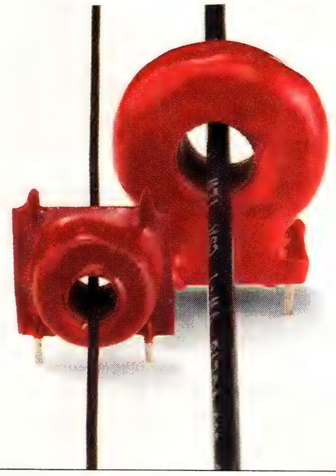

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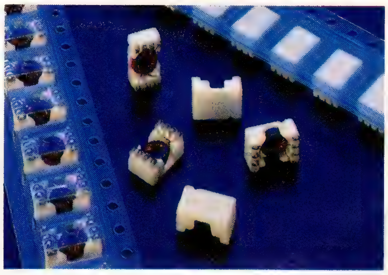

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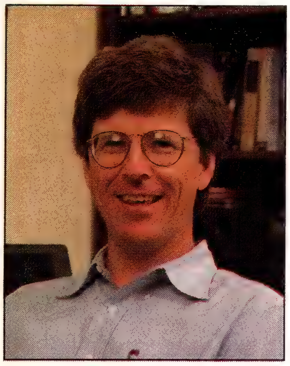

JACK GANSSLE,
EMBEDDED-SYSTEMS
CONTRIBUTING EDITOR

Read that data sheet!

When Steve Leibson, editor in chief of *EDN*, asked me to write a monthly column on embedded-system-hardware issues, I told him I wasn't sure I had enough to say to fill 2000 words a dozen times a year. Besides, this business changes so fast that all of us are constantly on the verge of becoming technological dinosaurs. Still, some basics of engineering never change, so I agreed to try and pound out a few pearls of wisdom each month.

I've been fortunate in being part of the µP revolution almost from the start. My first job as a (very) junior engineer was the design of 8008-based systems. In only a couple of decades, this industry has mushroomed from tiny embedded systems with 0.05-MIPS CPUs running 2k programs, to today's inexpensive 50-MIPS+ designs with millions of lines of code. It's amazing and breathtaking to see how far we've come in so little time.

> **I suspect that history will show the true revolution in the late 20th century occurred with the introduction of embedded µPs into every bit of our lives.**

While the popular press loves to babble on about the information society, focusing on the widespread availability of cheap PCs that look like computers to a nonengineer, I suspect that history will show the true revolution in the late 20th century occurred with the introduction of embedded µPs into every bit of our lives. If we could hear the collective hum of all µPs presently computing, we would be overwhelmed by this new paradigm of society.

It's a tragedy that the majority of humankind has no understanding of how their lives are subtly enhanced by the embedded µP. Instead, most people fret and fume if the ATM machine takes an extra second to dispense cash (or issue that oh-so-dreaded "insufficient funds" message), yet few understand that the machine is verifying the card, communicating with mainframes at Visa Central, debiting accounts, and electronically adjusting balances at banks all over the country, just to drop some pocket money into someone's impatient hands.

This lack of understanding creates widespread misconceptions about the nature of the computer industry. Eight-bit designers get no respect. After all, it's a 32/64-bit RISC/SPARC/DSP high-end 100-MIPs world—ain't it?

Well, no, it ain't. High-end CPUs account for just a fraction of the entire computer business. The tens of millions of 386 and up processors shipped are practically an insignificant blip compared with the five billion processors sold each year—most of which are 4- or 8-bit machines, and virtually all of which are buried inside millions of embedded systems.

Even in technical publications, fast and powerful processors get the glory, just as fast cars and flashy clothes get all of the attention in the popular press. And, just as Hollywood's favorites garner the majority of attention from the press while we, the less charismatic and less beautiful people, carry on the real work of society, so do little CPUs shoulder most of the computational burden of the world.

Similarly, although we read of vast team-design efforts and the thousands of people involved in coding big weapon systems or the latest Lotus masterpiece, I believe that most embedded systems are born of solitary designers or programmers working with just a few colleagues.

Unfortunately too many solo designers feel out of the mainstream of engineering, since the press focuses almost exclusively on the huge projects. Take heart, ye clever inventors changing the world! You are not working on obsolete technology just because your processor is a Z8 or 6805. Your tiny project team is not a throwback to the days of yore. Don't be lulled into thinking you are out of the mainstream.

I talk daily to dozens of design engineers in all corners of the globe. It seems the happiest are those working on smaller projects and in small groups, where their impact is immediately felt. Based on this information, I make the following disclaimer: since 4-, 8-, and 16-bit systems are

PHOTOGRAPHY / HOWARD DAVIS

just as important, and a lot more fun, than the minuscule high end of the market, this column will focus mainly on these sorts of systems.

Clock problems

I see a lot of embedded systems in my travels and get to take an under-the-hood look at most of these systems. Many are wonderfully designed; some are not. One persistent problem I see is a total disregard for data sheets.

For a number of years, embedded systems lived in a wonderful era of compatibility. Just about all of the signals on any logic board were relatively slow and generally TTL compatible. This lulled designers into a feeling of security, until far too many of us started throwing digital ICs together without considering their electrical characteristics. If one is 2.4V and a zero 0.7, if we obey simple fan-out rules, and as long as speeds are under 10 MHz or so, this casual design philosophy works well. Unfortunately, today's systems are not so benign.

Few µPs, in fact, have *ever* exclusively used TTL levels. Surprise! Pull out a data sheet on virtually any µP and look at the electrical-specs page—you know, the section without coffee spills or solder stains. Skip over those 300 tattered pages about programming internal peripherals, bypass the pizza-smeared pinout section, and really look at those one or two pristine pages of dc specifications.

Most CPUs accept TTL-level data and control inputs. Few CPUs are happy with TTL on the clock and/or reset inputs. Each chip has different requirements, but in a quick look through the data books, I came up with the following:

- 8086: Minimum V_{IH} on clock: V_{CC}-0.8
- 386: Minimum V_{IH} on clock: V_{CC}-0.8 at 20 MHz
  3.7V at 25 and 33 MHz
- Z80: Minimum V_{IH} on clock: V_{CC}-0.6
- 8051: Minimum V_{IH} on clock and reset: 2.5V.

In other words, connect your clock and maybe reset to a normal TTL driver, and the CPU is out of spec. The really bad news is that these chips are manufactured to behave far better than the specs, so they'll often run fine despite illegal inputs. If only they failed immediately on any violation of specifications. Then we'd find these elusive problems in the lab, long before shipping 1000 units into the field.

Fully 75% of the systems I see that use a clock oscillator (rather than a crystal) violate the clock-minimum, high-voltage requirement. It's scary to think we're building a civilization around embedded systems that may well be largely misdesigned.

If you drive your processor's clock with the output of a gate or flip-flop, be sure to use a device with true CMOS voltage levels. 74HCT is a good choice. Don't even consider using 74LS without at least a heavy-duty, pull-up resistor.

> **It's scary to think we're building a civilization around embedded systems that may well be largely misdesigned.**

Those little, silver 14-pin cans containing a complete oscillator are a good choice—if you read the data sheet first. Many cans provide TTL levels only. I'm not trying to be an alarmist here, but look in the latest DigiKey catalog—they sell dozens of varieties of CMOS *and* TTL parts.

Clocks must be clean; noise will cause all sorts of grief on this most important signal. It's natural to want to use a Thevenin termination to more or less match impedance on a clock routed over a long pc-board trace or even offboard. Beware! Thevenin terminations (typically a 220Ω resistor to +5 and a 270 to ground) will convert your carefully crafted CMOS level to TTL. Use series damping resistors to reduce the edge rate if noise is a problem. A pull-up resistor might help with matching impedance if the power supply has a low impedance (as it should).

A better solution is to use clock-shaping logic near the processor itself. If the clock is generated a long way away, use a CMOS-hysteresis circuit (like a 74HCT14) to clean it up. The extra logic adds delay, though. If your system requires clock synchronization, then use a special low-skew clock driver made for that purpose.

In slower systems—under 20 MHz or so—I prefer to design circuits that don't depend on a synchronous clock. What happens if you change to a second-sourced processor with slightly different timing? Keep lots of margin to prevent this from happening.

Never drive a critical signal like clock offboard without buffering it. There are a very few absolutely critical signals in any system that must be noise-free. Examine your design, determine what these signals are, and take appropriate steps. Clock, of course, is the first that comes to mind. Another is ALE (Address Latch Enable), used on processors with a multiplexed address/data bus. A tiny bit of noise on ALE can cause your address register to latch in the middle of a data cycle, driving an incorrect address to the memories.

Check the timing

OK, so now your voltage levels are right. Go back to the data sheet and make sure the clock's timing is in spec. The 8088 requires a 33%-clock duty cycle. Sure, it's a little odd, but this is a fundamental rule of nature to 8088 designers. Other chips have tight duty-cycle requirements as well.

Rise and fall times, though difficult to design for, are just as important. Some chips have *minimum* rise/fall time requirements. It's awfully hard to predict the rise/fall time for a track routed all over the board. That's one attraction of µPs with a clock-out signal. Provide a decent clock input to the chip, connect nothing to this line other than the processor, and then drive clock out all over the board.

Motorola's 68HC16 pulls a really neat trick: You can use a 32,768-Hz standard watch crystal to clock the device. An internal PLL multiplies this to 16 MHz and drives a clock out-

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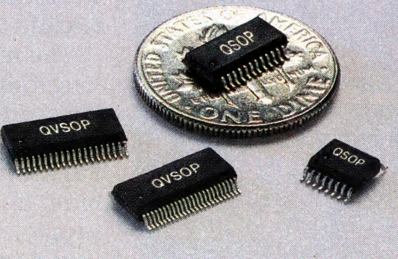

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put to feed to the rest of the board. This gets around many of the clock problems and gives a "free" accurate, time-of-day clock source.

The processor's reset input is another source of trouble. Like clock, some processors have unusual input-voltage requirements for reset. Be wary. Other chips require synchronous circuits. The old Z280 had a very odd timing spec, clearly spelled out in the documentation, which everyone ignored, only to find massive troubles getting the CPU to start. I think every Z280 design suffered from this particular ill at one time or another.

Always read the data sheets and don't skip over the electrical specifications with a mighty yawn.

Sometimes slew rate is also an issue. The old RC-startup circuit generates a long ramp that some processors cannot tolerate. You might want to feed it into a circuit with hysteresis, like a Schmitt trigger, to clean up the ramp.

The more complex CPUs require a long time to stabilize their internal logic after power-up. Reset cannot be unasserted until this interval goes by. Further complicating this is the ramp-up time of the system power supply, because the CPU will not start its power-up sequence until the supply is at some predefined level. The 386, for example, requires 2^{19} clock cycles if the self-test is initiated before it is ready to run.

Think about it. In a 386 system, four events are happening at once: The power supply is coming up, the CPU is starting its internal power-up sequence, the clock chip is still stabilizing, and the reset circuit is getting ready to unassert reset. How do you guarantee that everything happens to spec?

The solution is a long time delay on reset, using a circuit that doesn't start timing out until the power supply is stable. Motorola, Dallas Semiconductor, and others sell wonderful reset devices that clamp until the supply hits 4.5V or so. Use these in conjunction with a long time constant so the processor, power supply, and clocks are all stable before reset is released.

When Intel released the 188XL, it subtly changed the timing requirements of reset from that of the 188. Many embedded systems didn't function with this "compatible" part simply because they weren't compliant with the new chip's reset spec. The easy solution is a 3-pin reset clamp.

The moral

Always read the data sheets and don't skip over the electrical specifications with a mighty yawn. These details make the difference between a reliable production product and a life of chasing mysterious failures.

If you've read many annual reports from publicly held companies, you know that the real description of each company's situation is contained in the notes. This is just as true in a chip's data sheet. It seems no one specifies sink and source current for a µP's output, but the specification of the device's V_{OL} and V_{OH} will always reference a note that gives the test condition. This is generally a safe maximum rating.

Despite our apparently digital world, the harsh reality is that every component we use pushes electrons around. Electrical specifications are every bit as important to us as they are to an analog designer. Ignore those that would have you believe that designing an embedded system is nothing more than slapping logic blocks together.

Jack Ganssle is the president of Softaid, a vendor of emulators and other embedded-systems tools. His idea of heaven is sailing across oceans, although the ugly face of common sense precludes these dreams too often. He can be contacted via Compuserve at "76366,3333," or via Internet at "76366.3333@compuserve.com." For those users of the Pony Express, send mail c/o Softaid, 8310 Guilford Rd, Columbia, MD 21046.

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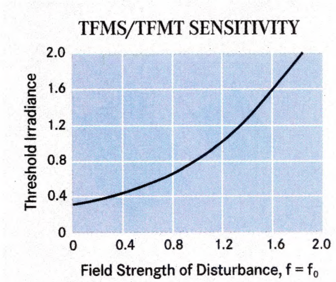

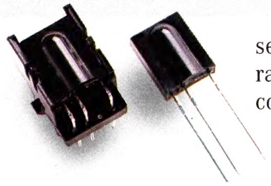

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